RESEARCH ON INNOVATIVE BITUMEN-BASED CARGOSFALT PRODUCTS IN ORDER TO EXTEND THE LIFE OF ROAD INFRASTRUCTURE MADE FROM ASPHALT MIXTURES OR CEMENT CONCRETE

Costel GHEORGHE[1], Dragoș-George POPESCU[2], Cătălin DIMA[3], Olguța CLADOVEANU[4]

Rezumat. *Expunerea în medii agresive, cum ar fi radiațiile ultraviolete, umiditatea, acizii și soluțiile saline produce o succesiune de modificări chimice în compoziția asfaltului, în special în procesul de oxidare care conduce la pierderea elasticității și a proprietăților adezive. Produsele prezentate sunt realizate pe bază de bitum, modificat cu un compus polimeric, având rolul de a prelungi durata de viață a drumului cu cel puțin 3 până la 5 ani de la aplicare. Materialele previn oxidarea suprafeței și descompunerea superficială prin blocarea apariției microfisurilor, cauzate de apă, eroziune, precum și de deteriorarea drumurilor. Produsele sunt ușor de aplicat și oferă o soluție economică pentru întreținerea drumurilor.*

Abstract. *Exposure to natural elements such as ultraviolet radiation, moisture, acids and saline solutions produces a succession of chemical changes in the composition of asphalt, especially in the oxidation process leading to the loss of elasticity and adhesive properties. The presented products are made on the basis of bitumen, modified with a polymer compound, with the purpose of extending the life of the road by at least 3 to 5 years from application. The materials prevent surface oxidation and surface decomposition by blocking the appearance of microcracks, caused by water, erosion and road damage. The products are easy to apply and offer an economical solution for road maintenance.*

Keywords: Road infrastructure, Bitumen treatment, Asphalt mixture, Concrete

DOI https://doi.org/10.56082/annalsarscieng.2023.2.45

1. Introduction

Asphalt is the most used material for covering roadways. During exploitation, asphalt is subjected to natural factors such as ultraviolet radiation, moisture, acids and saline solutions, which over time produce chemical changes in its composition, more precisely in the oxidation process leading to loss of elasticity and initial properties. The result of wear over time is the appearance of

[1] Eng., Senior Researcher CPI, INCERTRANS S.A, E-mail: costel.gheorghe@incertrans.ro
[2] Eng.-ROMIS TL 2004 S.R.L., Brasov, office@cargosfalt.eu
[3] Eng. Senior Researcher CPIII, INCERTRANS S.A, catalin.dima@incertrans.ro
[4] Chemist Eng., INCERTRANS S.A, Bucharest, olguta.chirita@incertrans.ro

microcracks, through which degenerative factors penetrate into the depth of the mixture, leading to a continuous corrosion process. As a result, alveoli appear, which turn into pits, the development of which eventually leads to the destruction of the entire asphalt carpet and at the same time cause damage to the means of transport that go through the road, as well as the disruption of traffic. [1]

In order to eliminate these shortcomings, the specialists sought methods of protection of the road surface, as well as other roadways, such as aviation tracks, so as to preserve their initial properties and extend their service life. [2]

This paper presents several products designed for the protection of surfaces covered with asphalt mixtures, as well as cement concrete. [3]

2. Experimental Study

The main laboratory determination by which one can analyze the resistance of an asphalt mixture to the formation of plastic deformations, as a result of repeated passed of a loaded wheel of the vehicles is the wheel tracking test (to the formation of the rut depth).

The rut depth is the permanent longitudinal deformation of the road structure, characterized by a subsidence of it under the effect of repeated demands from traffic. This phenomenon can occur on all types of roads, but is more evident on roads with heavy and heavy traffic. [4]

2.1. Studies on the behavior of asphalt mixtures using innovative bitumen-based products

The study presents the results of the tests on plates made from asphalt mixture of type BA16rul 50/70, asphalt mixture of type BA 16 rul 50/70 together with the product based on bitumen and anrobate aggregates, but also on concrete cubes taken during the construction of airport movement surfaces.

2.1.1 Performing the wheel tracking test with the asphalt mixture type BA 16 RUL 50/70 AT 70 °C

The first test for determining the depth of the rut of the asphalt mixture of type BA 16 rul 50/70 was at a temperature of 70°C, the plate not being covered with the product CARGOSFALT (UV) THERM. The test equipment allows a constant temperature to be maintained during the test, a temperature set in accordance with the climatic conditions in which the tested asphalt mixture is to be operated, adjustable and provided by a resistence fan (Figure 1).

Fig. 3. Fan to provide control of temperature on the equipment enclosure

To create an environment that also contains the influence of sun rays, a device that emits UV rays was used (Figure 2).

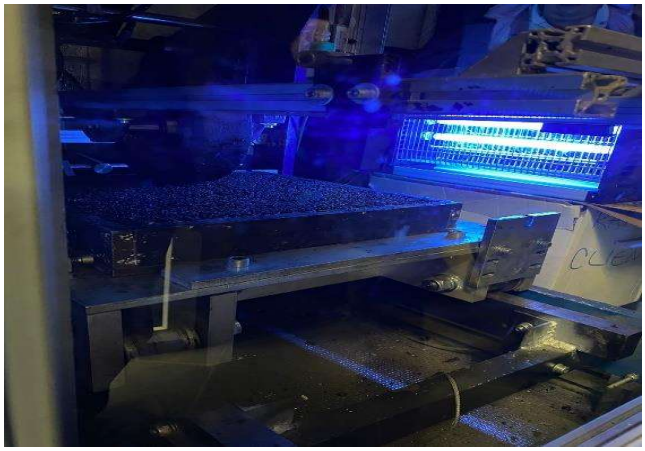


Fig 2. A device that emits UV rays

After the test, under the conditions of maintaining the temperature of 70°C and emitting the UV rays, a rut depth of 6.4%, respectively 2.56 mm was obtained.

In figure 3 it is presented the plate with asphalt mixing of type BA 16 rul 50/70 at the end of wheel tracking test.

Fig 3. The asphalt mixture after the wheel tracking test at 70°C

2.1.2 Performing the wheel tracking test with the mixture BA 16 RUL 50/70 covered with the product CARGOSFALT UV (THERM) and anrobate aggregates

At the wheel tracking test also tested the asphalt mixing plate of type BA 16 rul 50/70 with CARGOSFALT UV (THERM) product, over which an amount of anrobate aggregates was added.

In figure 4 it is presented the way of bedding of the product CARGOSFALT UV (THERM) over the asphalt mixture.

Fig 4. Preparing the plate with the asphalt mixture + CARGOSFALT UV (THERM) product

In figure 5 it is presented the plate over which the CARGOSFALT UV (THERM)

product was laid and over which the anrobate aggregates were laid, prepared for the wheel tracking test at 70 °C and with the emission of UV rays.

Fig 5. The plate with asphalt mixture and the product CARGOSFSLT UV (THERM)+anrobate aggregates

Fig 6. Roller sled of the wheel tracking test equipment

In figure 7 it is presented the footprint left by the running system of the equipment after the wheel tracking test.

Fig 7. Footprint on the plate with asphalt mixture and the product CARGOSFALT UV (THERM)

After the test, the depth of the rut was 5.9%, respectively 2.40 mm.

Table 1. Results obtained from the wheel tracking test

No.	Sample name	Temperature inside the equipment	Results obtained		Performance, according to SR EN 13108-1 (at 60ºC)		Test standard
			Wheel tracking rate mm/10^3 cycles	The depth of the rut %	Wheel tracking rate mm/10^3 cycles	The rut depth	
1	Asphalt mixture type BA 16 Rul 50/70	70ºC + UV radiation	0,23	6,40	WTSair0.30	PRDair7.0	SR EN 12697-22
2	Asphalt mixture type BA 16 rul 50/70+CARGOSFALT THERM and anrobate aggregates 2/4mm	70ºC + UV radiation	0,05	5,90	WTSair0.05	PRDair7.0	

2.2. Studies on the behavior of cement concrete using the innovative products CARGOSFALT T (treatment) based on bitumen

In the test, the water penetration depth was determined using 6 (six) concrete cubes measuring 150x150x150x150mm as samples. Three cubes were considered

without intervening on them and three cubes were treated on the face exposed to the water pressure in the test facility with the product CARGOSFALT (TREATMENT).
In figure 8 it is presented the blank samples and the test-ready CARGOSFALT treated cubes.

Fig 8. Reference concrete cubes and treated concrete cubes with CARGOSFALT

The tests were carried out following the provided procedure in SR EN 12390-8. [5]

Table 2. Results obtained from the depth of water penetration

No.	Material tested	Water penetration depth (mm)			Average depth (mm)
1	Witness evidence	16	21	48	28
2	Sample treated with CARGOSFALT T (treatment)	10	15	11	12

As shown in the values shown in the table, the reference samples have a lower water penetration depth, resulting in the CARGOSFALT T (TREATMENT) product having a role to protect concrete surfaces at action of water penetration.

2.3. Studies on the cold-stocable mixture with milling aggregates

The study presents the physico-mechanical characteristics of a cold-made asphalt mixture recipe consisting of milled aggregates and additive CARGOSFALT A (ADDITIVE).

The materials used are milling aggregates sort 0-4 mm, 4-8 mm, 8-16 mm and additive CARGOSFALT A (ADDITIVE).

The granulometry of aggregates and the limits in accordance with the regulations AND 605, AND 025 [6] and the European standard SR EN 13108-1 are presented in the following table and figure:

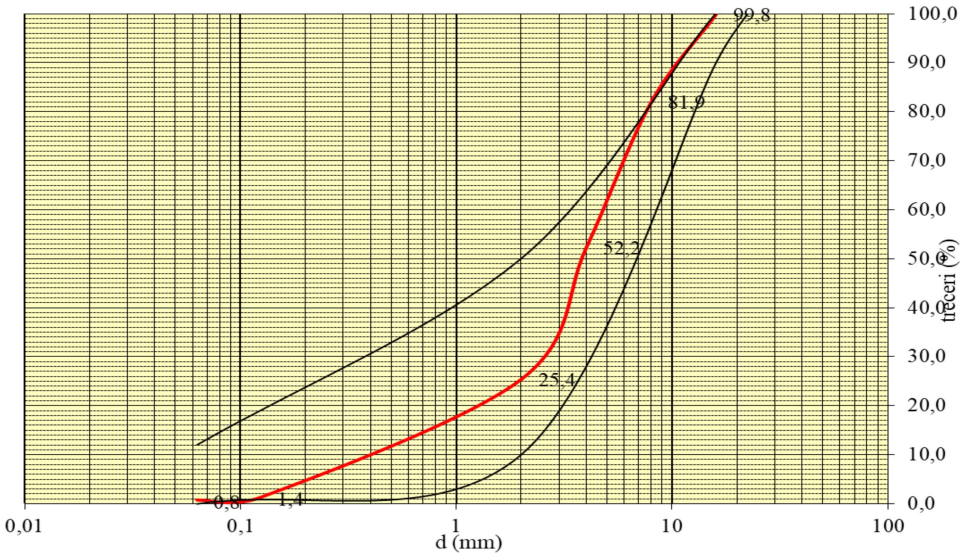
RECIPE I

Granulometry of aggregates, including the filler

Material	Sort	Passes (%) through sieves (mm)					
		0.063	0.125	2	4	8	16
CR	8-16	0,0	0,0	0,0	0,6	10,1	99,1
CR	4-8	0,0	0,0	0,7	7,3	99,6	100,0
NC	0-4	1,5	2,7	50,3	99,7	100,0	100,0

Study of mineral skeleton

Material	Percentages	Granulometry of the mixture (passes to (%)					
		0.063	0.125	2	4	8	16
CR 8-16	20	0,0	0,0	0,0	0,1	2,0	19,8
CR 4-8	30	0,0	0,0	0,2	2,2	29,9	30,0
NC 0-4	50	0,8	1,4	25,2	49,9	50,0	50,0
total	100	0,8	1,4	25,4	52,2	81,9	99,8



Limits according to SR EN 13108-1.

The granulometric curve is within the limits of SR EN 13108-1.

Marshall specimens were made in the impact compactor, applying 75 kicks to each side of the sample at ambient temperature. The amount of CARGOSFALT A (ADDITIVE) additive was 2.4% of the mixture.

After studies, the mixing samples being tested as a warm-prepared asphalt mixture, determining the following characteristics:

- Apparent density – SR EN 12697-6;

- Water absorption – AND 605;

- Marshall stability – SR EN 12697-34.

Additionally, to check the behavior as a stocable mixture, cohesion was determined at -10^0C – SR 13576.

The tests were performed on samples held in the air aged 14 to 16 days.
The tests results are shown in the following table:

The physical and mechanical characteristics determined on the asphalt mixture

Characteristic of the mixture	U.M	Values obtained	Test method
Additive content in the mass of the mixture	%	2.4	
Apparent density	Mg/m3	2.053	SR EN 12697-6
Water absorption, vol	%	9.5	AND 605
Marshall stability, at 60^0C	kN	0.4	SR EN 12697-34
Flow index (Marshall flow), at 60^0C	mm	9.0	SR EN 12697-34
S/I ratio	kN/mm	0.04	SR EN 12697-34
Cohesion at -10^0C	%	86.6	SR 13576

In the study was tested a Marshall stability sample, which was kept in the air at a temperature of 15.5ºC. The resulting values were:

- Marshall stability= 7.6 KN;
- flow index = 7.0 mm

In order to obtain better values of the characteristics of the asphalt mixture, a mixture recipe was developed:

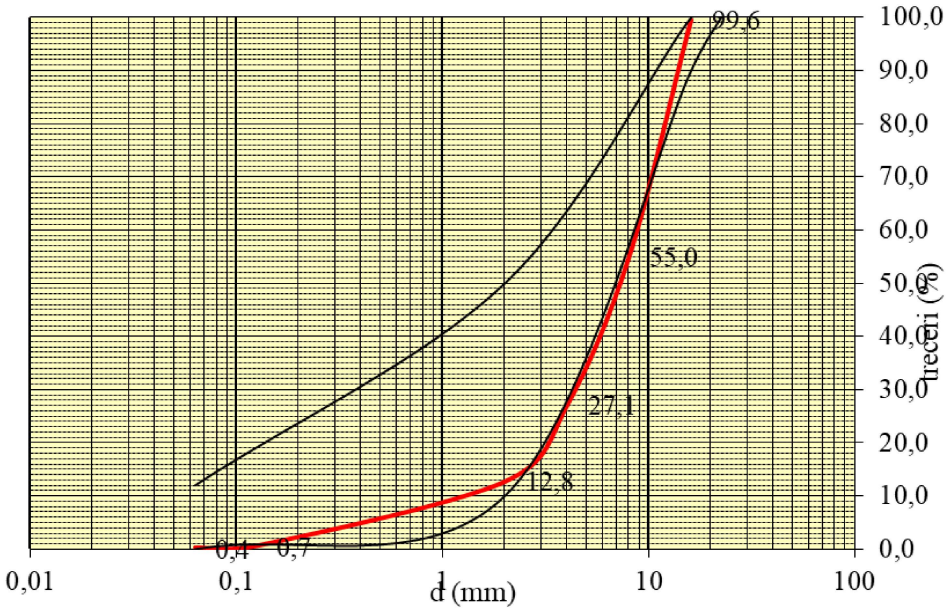
RECIPE II

Granulometry of aggregates, including the filler

Material	Sort	Passes (%) through sieves (mm)					
		0.063	0.125	2	4	8	16
CR	8-16	0,0	0,0	0,0	0,6	10,1	99,1
CR	4-8	0,0	0,0	0,7	7,3	99,6	100,0
NC	0-4	1,5	2,7	50,3	99,7	100,0	100,0

Study of mineral skeleton

Material	Percentage	Granulometry of the mixture (passes to (%)					
		0.063	0.125	2	4	8	16
CR 8-16	50	0,0	0,0	0,0	0,3	5,1	49,6
CR 4-8	25	0,0	0,0	0,2	1,8	24,9	25,0
NC 0-4	25	0,4	0,7	12,6	24,9	25,0	25,0
Total	100	0,4	0,7	12,8	27,1	55,0	99,6



Limits according to SR EN 13108-1.

The granulometric curve is within the limits of SR EN 13108-1.

Marshall specimens were made at the impact compactor, applying 100 kicks to each side of the sample at ambient temperature. The amount of CARGOSFALT A (ADDITIVE) was 2.6% of the mixture.

The following characteristics have been determined :

- Apparent density – SR EN 12697-6 ;
- Water absorption – AND 605 ;

- Marshall stability – SR EN 12697-34.

The tests were performed on samples kept in the air aged 3 days and 10 days.

The test results are shown in the following table:

The physical and mechanical characteristics determined on the asphalt mixture

Characteristic of the mixture	U.M	Values obtained		Test method
The age of samples	days	3	10	
Additive content in the mass of the mixture	%	2.6	2.6	
Apparent density	Mg/m3	2.163	2.179	SR EN 12697-6
Water absorption, vol	%	4.81	3.86	AND 605
Marshall stability, at 20^0C	kN	7.09	7.60	SR EN 12697-34
Flow index (Marshall flow), at 20^0C	mm	1.91	2.81	SR EN 12697-34

3. Conclusions

I. The first test for determining the depth of the rut of the asphalt mixture of type BA 16 rul 50/70 was at 70 °C, the plate not being covered with the product CARGOSFALT THERM. After the test, under the conditions of maintaining the temperature of 70°C and emitting the UV rays, a rut depth of 6.4% and 2.56 mm was obtained, respectively.

The second test for determining the depth of the rut of the asphalt mixture of type BA 16 rul 50/70 was at 70 °C, the plate being coated with the product CARGOSFALT UV (THERM) and anrobed aggregates. After the test, under the conditions of maintaining the temperature of 70°C and emitting the UV rays, a rut depth of 5.9% and 2.40 mm was obtained, respectively.

As a result of laboratory testing, it is found that the best behavior is the plate-mix assembly covered with the CARGOSFALT product (THERM) and anrobate aggregates.

Comparing these two test results, it follows that the reduction in the depth of the rut due to the use of the whole package of CARGOSFALT UV (THERM) and anrobate aggregates) is 7.8%.

All the results for resistance to permanent deformation are very good, being registered at the maximum depth performance of the 7% track, that is in the category P_7, according to SR EN 13108-1.

II. As a result of the determination of the depth of water penetration into concrete, it has emerged that the CARGOSFALT product (TREATMENT) has a role to protect the concrete surfaces from the action of water penetration.

III. Following the analysis and interpretation of the results obtained on the cold-executed asphalt mixture with milling aggregate and additive CARGOSFALT A (ADDITIVE), the following results:

- the asphalt mixture can be used as a storable asphalt mixture because it meets the requirements of AND 025 and SR 13576, respectively apparent density > 2000 kg/m3, cohesion at -10^0C > 80%;

- in order for the mixture to meet the requirements of AND 605, studies (tests) will be carried out, on a case-by-case basis, on the stability of Marshall determined according to SR EN 12697-34 in water, minimum 40 minutes at 60^0C;

- the breaking force of test specimens kept in the air for 14 days, not kept in water at 600C and tested at Marshall Press at 15.5^0C, increased with the increase in the percentage of sort aggregates 8-16 mm;

- the asphalt mixture with cold-prepared milled aggregates can be used as a base layer for county, municipal and local roads;

- this is an economical solution obtained if milling aggregates are used.

IV. The development of scientific research in areas aiming to increase the life of infrastructure works in road transport by promoting innovative products is an important aim resulting in saving materials used, energy and environmental protection.

REFERENCES

[1] Nicoleta Mariana ENE, Costel GHEORGHE, Cătălin DIMA, *The use of asphalt mixtures in road structures,* **13, 1/2021,** Productica Scientific Session

[2] Costel GHEORGHE, Cătălin DIMA, Nicoleta Mariana ENE, Laurențiu STELEA, *The use of asphalt mixtures whern creating airport movement surfaces,* **13, 1/2021,** Productica Scientific Session

[3] EN 13108-1 Bituminous mixtures. Material specifications. Part 1: Asphalt concrete

[4] EN 12697-22 Bituminous mixtures. Test methods for hot mix. Asphalt. Part 22: Wheel tracking

[5] EN 12390-8 Testing hardened concrete. Part 8: Depth of penetration of water under pressure

[6] The normative on asphalt mixtures made in hot weather. Technical conditions for the design, preparation and implementation of asphalt mixtures". Indicative AND 605-2016, issue on 29.11.2017.