INNOVATIVE PRODUCT FOR STABILIZATION, WATERPROOFING, DUST ALLAYING AND CONTROLING SOIL EROSION FOR UNPAVED ROADS

Monica COSTEI[1], Costel GHEORGHE[2],
Cătălin DIMA[3], Carmen ILIN-IANCU[4], Nicoleta ENE[5]

Rezumat. *Lucrarea prezintă avantajele utilizării unei solutii ecologice cu rol de control asupra prafului și de impermeabilizare a suprafețelor neasfaltate dar și de stabilizare a solului. Produsul oferă o soluție de neegalat fiind extrem de eficientă în combaterea prafului la nivel mondial. Acest produs a fost conceput ca o alternativă non-corozivă și ecologică utilizat pentru drumurile rutiere, cu rol de a elimina dispersarea particulelor de praf în atmosferă rezultate în urma traficului rutier. Produsul este ecologic și biodegradabil și își determină eficacitatea principală prin puterea de întărire și actionare asupra particulelor de praf legandu-le între ele și formând astfel o peliculă care se comportă ca o barieră fizică pe suprafața solului. Pelicula intărită prezintă stabilitate și rezistență pe suprafața solului în urma contactului dintre produsul ecologic și particulele de praf, oferind rezultate de impermeabilizare pe termen lung.*

Abstract. *The paper presents the advantages of using an ecological solution with the role of dust control and waterproofing of unpaved surfaces but also of soil stabilization. The product offers an unparalleled solution being extremely effective in allaying dust worldwide. This product has been designed as a non-corrosive and environmentally friendly alternative used for roads, with the role of eliminating the dispersion of dust particles in the atmosphere resulting from road traffic. The product is ecological and biodegradable and determines its main effectiveness by the strength of hardening and action on dust particles by bonding them together and thus forming a film that acts as a physical barrier on the soil surface. The hardened film shows stability and resistance on the soil surface following the contact between the ecological product and the dust particles, offering long-term waterproofing results.*

Keywords: Dust allaying, controling soil erosion

[1] Eng., Transport Research Institute SC INCERTRANS SA, Calea Griviței 391-393, Bucharest, Romania (monica.marinca@incertrans.ro).
[2] CP1 Senior researcher, Transport Research Institute SC INCERTRANS SA, Calea Griviței 391-393, Bucharest, Romania (costel.gheorghe@incertrans.ro).
[3] CP3 Researcher, Transport Research Institute SC INCERTRANS SA, Calea Griviței 391-393, Bucharest, Romania (cd_incertrans@yahoo.com).
[4] CP3 Researcher, Transport Research Institute SC INCERTRANS SA, Calea Griviței 391-393, Bucharest, Romania (carmen.ilin@incertrans.ro).
[5] Eng., PhD student, Transport Research Institute SC INCERTRANS SA, Calea Griviței 391-393, Bucharest, Romania (nicoleta.ene@incertrans.ro).

1. Introduction

The product for soil stabilization and dust allaying is used on the following types of surfaces:

- unpaved roads;
- construction sites;
- exploitation roads;
- access roads;
- mining roads;
- parking;
- access roads;
- sterile dump;
- deposits.

The product is characterized by the following advantages:

- dust control on unpaved road surfaces;
- by the long-lasting effect of waterproofing;
- ease of application through the use of standard equipment and technology;
- cost savings;
- is an ecological, non-hazardous water-based product;
- has no negative side effects on the environment;
- does not damage the vegetation on the side of the road;
- the traffic can be resumed after approximately 1 hour from the application of the solution on the soil surface, depending on the meteorological conditions and the type of soil.

It is an ecological product with the following components:

- water;
- lignosulfonic acid;
- brucit;
- sugar;
- silicates;
- carbonates.

The product has been designed in the following variants depending on the mixing method and the type of application: liquid; concentrated liquid; powder.

The product is mixed with water in proportion starting from 100 ml product / 1 liter of water, up to 1000 ml products / 1 liter of water, depending on the characteristics of the soil (dusty, fine sterile particles, humidity).

The solution is applied to any type of soil using a tanker truck, with a rear-mounted distribution bar that spreads the liquid. After spraying, the solution penetrates the soil forming a film with high tensile strength.

Once dry, the film becomes flexible, without cracks, providing a waterproofing of the soil, thus eliminating the dispersion of dust particles in the atmosphere due to road traffic.

2. Analysis of the product in the form of liquid and concentrated liquid in the INCERTRANS Laboratory

In the INCERTRANS Laboratory, specimens in the form of cylinders were made in two variants, namely:

- Cylinders made of earth with the optimum compaction humidity, using a solution with a concentration of 0.5% of the product in liquid form;
- Cylinders made of earth with the optimum compaction humidity, using a solution in the form of a concentrated liquid (100 l concentrated liquid at 20000 l water).

After manufacture, the cylinders were compacted in the press. After they have been produced, the specimens were stored for 7 days in the laboratory at ambient temperature and sprayed again with the solution.

Below are the results of the laboratory tests.

a) Determining the granularity of the soil according to STAS 1913 / 5-1985 (results in Table no 1)

Dry soil density, ρd, is the ratio of dry land mass to volume (including voids). The method consists in determining the mass of the soil and the volume of a soil specimen in the dry, wet or saturated state and calculating its density.

Table no 1

No.	Determined characteristics		Test number				
			1	2	3	4	5
1.	Mass (m_m)	g	1670,9	1703,8	1772,1	1836,3	1828,5
2.	Volume of compacted material (V)	cm^3	950,0	950,0	950,0	951,0	952,0
3.	Density ($\rho=m_m/V$)	g/cm^3	1,759	1,793	1,865	1,931	1,921
4.	Average humidity (w)	%	15,90	17,60	18,40	22,20	27,00
5.	Dry density ($\rho d=\rho/(1+w/100)$)	g/cm^3	1,518	1,525	1,575	1,580	1,512

b) Determination of plasticity limits according to STAS 1913 / 5-1985 (results in Table no 2)

The plasticity limits of cohesive soils provide information on the influence of water content on their geotechnical properties. Knowing the limits of plasticity provides a qualitative / quantitative indicator regarding the behavior under load of cohesive soils.

- lower limit - earth cylinder method

- upper limit - cup method.

Table no 2

	Upper limit				Lower limit		
	Test 1	Test 2	Test 3	Test 4	Test 1	Test 2	Test 3
watch glass tara (g)	18,40	27,50	21,20	21,00	23,40	14,80	23,60
initial mass of the sample (g)	30,70	41,40	35,20	36,90	28,20	19,20	26,50
dry mass of the sample (g)	27,10	37,50	31,40	32,70	27,20	18,30	25,90
humidity (%)	41,4	39,0	37,3	35,9	26,3	25,7	26,1
number of strokes	11	20	28	46	W_P=26,0%		
	W_L=37,8%						
IP = W_L - W_P = 11,8%							

c) Determination of compaction characteristics by PROCTOR test STAS 1913 / 13-1985 (results in Table no 3)

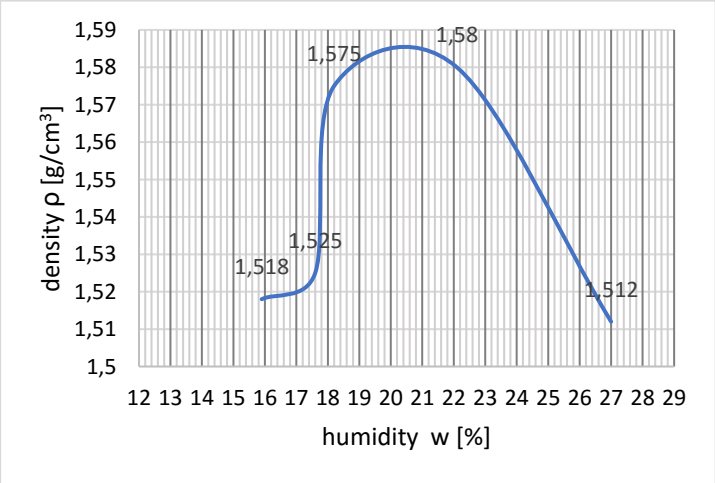
The method consists in determining the volume weight (density) of the compacted layer and its ratio to the maximum density in the dry state, found by the Proctor test, performed on the material used.

PROCTOR compaction tests, for determining the compaction characteristics, establish the relationship between the nature of the soil, humidity (w) and dry weight (qd).

The value of the optimum compaction humidity (w_{opt}) corresponding to the maximum dry weight volume (ρd_{max}) is retained from the compaction diagram.

Table no 3

compaction characteristics	U.M.	Value
optimum humidity in the humid field (w_{opt})	%	20,6
dry density, maximum in the wet domain ($\rho d_{maxumed}$)	g/cm^3	1,585



After determining the compaction characteristics (w_{opt} and ρd_{max}), the cylinders were subjected to the determination of the mechanical characteristics regarding the compressive strength after 7 days, according to STAS 10473/2.

d) Determination of compressive strength according to STAS 10473/2

The compressive strength is calculated after determining the maximum breaking force with the following relation:

Rc = F / A [N / mm2]

where,

Rc - is the compressive strength, in N/mm^2 (MPa);

F - maximum breaking force of the test piece, in N;

A - initial cross - sectional area of the test piece, in mm$_2$.

- cylinders made with concentrated liquid solution

Table no. 4

Test no.	Diameter d (mm)	Height h (mm)	Area (mm^2)	Breaking force (N)	Compressive strenght per cylinder (N/mm^2)	Correction coefficient depending on h/d	Compressive strenght
1	69,6	67,2	3802,7	21200	0,988	5,58	5,51
2	69,6	68,1	3802,7	22700	0,989	5,97	5,91
3	69,6	68,4	3802,7	22000	0,991	5,79	5,74
Average							**5,72**

- cylinders made with liquid solution

Table no. 5

Test no.	Diameter d (mm)	Height h (mm)	Area (mm^2)	Breaking force (N)	Compressive strenght per cylinder (N/mm^2)	Correction coefficient depending on h/d	Compressive strenght
1	69,6	68,5	3802,7	18800	0,994	4,94	4,92
2	69,6	68,0	3802,7	18000	0,989	4,73	4,68
3	69,6	68,3	3802,7	18500	0,991	4,87	4.82
Average							**4,80**

Conclusions A:

Following the results (accordind to Table no 4 and Table no 5), it is observed that the values for compressive strength, determined after 7 days from manufacture, namely 5,72 N / mm^2 (concentrated liquid product) and 4,8 N / mm^2 (liquid product) correspond to the requirements of STAS 10473/1 for soil stabilization.

3. Product analysis in the form of liquid and concentrated liquid in the Geotechnical Laboratory within the Technical University of Constructions Bucharest

Within the Geotechnical Laboratory, samples of untreated cohesive bag type 3 and cohesive bag (dusty clay) treated with 6% liquid product and 8% concentrated liquid for determining the shear strength by triaxial compression, according to STAS 8942/2.

Shear strength is the tangential stress that is exerted along the breaking surface at the time of failure. In the case of cohesive soils, the shear strength is expressed according to two parameters, namely:

- cohesion (c), constant in relation to the applied pressure, defined as the effect of the isotropic forces of attraction between the earth particles, uniformly distributed in its mass and which is, in fact, the resultant.

- internal friction angle (ϕ).

The following are the parameters of the direct shear strength of untreated cohesive soil (table no. 6) and of cohesive soil treated with water solution +8% concentrated liquid (table no. 7) and of cohesive soil treated with water solution +6% liquid (table no. No. 8)

a) Cohesive soil type 3, P05-1004 - untreated soil

Table no. 6

Shear strenght parameters							
ϕ:	24,5		Mohr-Coulomb	M.I.T.	β:	22,5	
c:	83,8	kPa			d:	76,3	kPa
ϕ':	26,.0				β':	23,6	
c':	78,6	kPa			d':	70,7	kPa
Test: Triaxial compression							
v: 0,5 mm / min							

b) soil treated with concentrated liquid product

Table no. 7

Shear strenght parameters							
ϕ:	25,2		Mohr-Coulomb	M.I.T.	β:	23,0	
c:	119,2	kPa			d:	107,9	kPa
ϕ':	26,2				β':	23,8	
c':	113,4	kPa			d':	101,7	kPa
Test: Triaxial compression							
v: 0,5 mm / min							

c) soil treated with liquid product

Table no 8

Shear strenght parameters							
ϕ:	25,7		Mohr-Coulomb	M.I.T.	β:	23,4	
c:	107,6	kPa			d:	97,0	kPa
ϕ':	26,9				β':	24,3	
c':	105,9	kPa			d':	94,4	kPa
Test: Triaxial compression							
v: 0,5 mm / min							

Conclusions B:

The triaxial compression test resulted in the following cohesion values (c):

- 83,8 kPa in the case of untreated soil
- 119,2 kPa in the case of soil treated with concentrated liquid product
- 107,6 kPa in the case of soil treated with liquid product

From the obtained results there is an increase of the cohesion value by 42.2% in the case of the soil treated with the concentrated liquid product, respectively 28.3% in the case of the soil treated with the liquid product. The obtained results correspond to the soil waterproofing requirements.

The product is obtained entirely from natural minerals, it is absolutely safe and environmentally friendly. It is designed to allow rapid film formation on the road, to increase adhesion to the substrate, water absorption and application flexibility.

R E F E R E N C E S

[1] Agrement tehnic 004-07/1581-2019- Produs ecologic pentru impermeabilizarea si eroziunea solului DUST STOP MUNICIPAL BLEN / Technical approval 004-07/1581-2019 - Ecological product for waterproofing and soil erosion DUST STOP MUNICIPAL BLEN

[2] STAS 10473-1 – Straturi din aggregate naturale stabilizate cu ciment / Layers of natural aggregates stabilized with cement

[3] STAS 8942/2 – Forfecarea directa a pamanturilor / Direct shearing of land

[4] https://www.cypherenvironmental.com/products/dust-stop/