ARTIFICIAL AGGREGATES USED TO ROLLING LAYERS

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Abstract: *This study of scientific research makes known the possibility of substitution of materials from natural origin with materials resulting from the processing of industrial waste. By using aggregates from artificial origin, quarry aggregates replace the natural origin aggregates, which are obtained by exploiting the natural rock mountains, thus affecting both flora and fauna of the mountains and the country's mineral resources reserve. Using aggregate type Lidonit for the periodic maintenance of roads, works that have a frequency of 2-4 years, would increase consumption of these aggregates, slag default consumption, thus reducing surface storage platforms for steelworks slags (storage area slags have become an issue for Environment).*

Key words: *SYNTHETIC AGGREGATES (LIDONIT), ECOLOGICAL TECHNOLOGY.*

1. Introduction

In the current regime of using and turning waste in various ways (recycling.) to highlight the qualities of artificial origin aggregates used in road layers subjected to great wear, we determined geometric characteristics of several types of aggregates in the laboratory so that it could be possible to compare them.

2. Assumptions - basic steps

1. Study objective: establishing the recipe of preparation for the asphalt mixtures poured for execution of carpets cold asphalt very thin - rolling layer or reshaping layer of some kind as AND 523-2003. (0/4, 0/8, 0/10).

2. Reference: according to the attached bibliography.

3. Work Plan of Study

3.1 Determining the technical characteristics of bituminous emulsion that will be used: cationic bituminous emulsions with slow break type EBmCL 65.

The technical characteristics that will be determined on the emulsion type EBmCL65, through laboratory tests, are the following:

- bituminous binder content;
- consistency: rest on the wire cloth sieve with 0.63 mm;
- remnant on the sieve of 0.5 mm;
- storage stability (rest on the wire cloth sieve with 0.63 mm after 7 days);
- rest on the sieve of 0.5 mm after 7 days of storage;
- tendency to decantation after two days of storage;
- tendency to decantation after three days of storage;
- Engler pseudo - viscosity at 20 ° C;
- IB - breakage index (Sikaisol filler method);
- pH emulsion;
- stability at transport ;
- adhesion from the natural aggregates used;
- binder recovered from the emulsion characteristics - ductility at 25 ° C;
- consistency of the binder recovered from the emulsion, at intermediate temperature of operation - penetration at 25 ° C;
- the cohesion of the recovered binder - elastic recovery at 130° C.

Is checked practicality that the used emulsion to have characteristics comply with the regulations in use (thus eliminating the possibility of generating non-compliance). It will be used only the emulsion that meets these requirements.

3.2 Determination of physico-mechanical properties of aggregates to be used

The laboratory tests are used to determine whether the physico-mechanical properties of aggregates and cement / filler, are complying with the provisions of the standards and regulations.

For the Aggregates will be determined:

- granularity;
- content of soft, altered, friable, porous and vacuolar granules;
- resistance to crushing by compression when dry;
- coefficient of accelerated grinding ;
- quantitative adhesion to EBmCL65;
- clay content (blue value);
- form coefficient;
- parts fine as 0.01 mm;
- Los Angeles wear;
- Resistance to freezing - thawing (coefficient of frost cleftness, sensitivity to frost);
- Resistance to repeated action of Na_2SO_4;

For filler will be determined:

- fineness of grinding;
- humidity.

For cement will be determined:

- initial hardening time;
- constant volume;
- compressive strength: to 2 days, to 7 days and to 28 days.

Will be used only those products that meet the provisions of the rules and regulations in use.

3.3. Establishing the mixture of natural aggregate for the reshaping layer / required runtime layer.

To determine the composition of the mixture of aggregates required to obtain asphalt mixture poured at cold, will be determined, by mathematical calculation, based on the granulometry of each type of apron in hand, dosages of mixing the components so that the granularity of the mixture to subscribe in the curves from table no. 1.

Ssorts of work are mixed in these percentages and is checked the granularity mixture obtained in order to be sure that we adhere to prescribed curve.

We propose several options of dosages for selecting the best solution for the mixture of the aggregates, after analysing the grading curve of the mixture of aggregate.

Mixed aggregates were selected based on the content of clay and on the value of the bitumen emulsion type EBmCL65 adhesion and the integration of them closer to the average curve for each type of mixture recommended in part.

3.4. Preparation and testing of asphalt mixture:

There are prepared in laboratory, several samples of asphalt mixtures poured at cold using the bitumen emulsion EBmCL type, selected with at least three mixed aggregates which correspond to the granulometric composition required to the type of mixture recipe and at least 3 dosages of emulsion.

Preliminary attempts consisted in changing the dosages of bituminous emulsions - prewatered water, cement, additive controller breaking (breaking retarders) etc..

For preparing the samples of cast asphalt, the natural aggregates were dried to constant mass. Each sample performed will be analysed in the following ways: workability, start of the hardening, time of mixing, emulsion breaking start. The recipes are selected according the results obtained regarding the mixing time, the breaking time of the emulsion, consistency.

The main characteristics that are determined on the asphalt mixture are:

- workability;
- consistency;
- time of breaking the emulsion from the freshly prepared mixture;
- pH water from breaking the emulsion;
- adherence to the substrate mixture;

3.5 Selecting the best recipe for obtaining asphalt mix

Optimal recipe, obtained under laboratory conditions, for preparation of the asphalt poured cold, for execution of the thin

layer asphaltic layer, retraining and / or rolling layer, such as AND 523-2003, using materials with technical characteristics according to the requirements of the specifications and literature is the recipe that leads to a cold mixture cast with the best physical and mechanical characteristics.

3.6 Conclusions

Percentages of each material are given indicating the sources for each component. To highlight the characteristics of slag from steelworks aggregates we present below a comparison between results obtained with aggregate mixture from three different sources using two types of cationic bituminous emulsions with slow breaking polymer modified bitumen:

Aggregates

- Bicsad aggregates (Romania) : C 4/8; NC 0/4
- Kusser granite aggregates (Germany): C 4/8; NC 0/4
- Lidonit – DSU Galați (Romania): C 4/8

The first two types of aggregates are widely used in the production of cold Thin bituminous layers. The third aggregate is the object of study in this research paper.

Bituminous emulsion type EBmCL 65:

- emulsion type EbmCL65 made with emulsifiers from Giurgiu Chemical Poll and bitumen Lotus Poland by PA&CO International.
- emulsion type Ralumac EbmCL65 for airport runways, manufactured by SC Systematic Arad.

EBmCL65 emulsion type made with emulsifiers by Giurgiu Chemical Poll and bitumen Lotus Poland with Bicsad aggregates was used in the current maintenance of DN1 road in Turda city and Ralumac emulsion type with granite Kusser aggregates (Germany) was used at the repairing works to track 2 from Otopeni Airport.

Physico-mechanical properties of aggregates

Aggregate quarries. We used the following sources:

- Bicsad aggregates (Romania) : C 4/8; NC 0/4
- Kusser granite aggregates (Germany): C 4/8; NC 0/4
- Lidonit – DSU Galați (Romania): C 4/8

3. Description of the laboratory works

In the laboratory works were used the following bituminous emulsions:

- EBmCL65 emulsion type made with emulsifiers from the Giurgiu Chemical Poll and bitumen Lotus Poland;
- Ralumac Emulsion type for airport runways, manufactured by SC Systematic Arad.

Table no. 1. *Characteristics bituminous emulsions*

No.	Characteristics analyzed	Ralumac Values	EbmCL 65 Values	U.M.	Standard SR 8877-1/2007 Standard AND
1.	Residual birumen content	64,45	64,23	%	60 – 65
2.	Consistency: rest on the wire cloth sieve with 0.63 mm	0,00	0,00	%	max 0,1
3.	Engler pseudo - viscosity at 20 ° C	5,5	5,8	^{o} E	min 5
4.	IB - breakage index, first method	128	120	-	min 120
5.	pH emulsion	2,22	1,44		
6.	Storage stability (rest on the wire cloth sieve with 0.63 mm after 7 days)	0,0	0,0	%	max 0,5
7.	Stability at transport	0,44	0,62	%	max 0,5
8.	Adhesion of the emulsion to the natural aggregates (quantitative method) - Biscad aggregates (andesite) - Kusser aggregates (granite 4/8 – Germany) - Lidonit 4/8	98,53 94,32 91,09	100,0 97,32 92,23 90,28	%	min 90
9.	Characteristics for the bitumen extracted from emulsion				
	a) penetration	68	62	1/10 mm	65 - 100
	b) ductility	110	107	cm	min 100
	d) elastic recovery at 13 ^{o}C	55	54	%	min 40

In their composition were used aggregates from the following sources:

- Bicsad aggregates (Romania) : C 4/8; NC 0/4
- Kusser granite aggregates (Germany): C 4/8; NC 0/4
- Lidonit – DSU Galați (Romania): C 4/8.

Table no.2 *Size composition of the aggregates:*

Materials, %	Rock type	Passing the sieve or strainer of ... mm, %						
		10,0	8,0	4,0	2,0	1,0	0,63	0,10
C 4/8 Bicsad	Andesite		95	10	2	2	2	1
NC 0/4 – Bicsad	Andesite		100	97	69	51	43	16
C 4/8 – Kusser Aicha	Granite		98.5	7.4	4.2	3.1	1.3	0.8
NC 0/4 Kusser	Granite		100.0	96.7	56.1	43.7	31.1	8.7
Lidonit 4/8	Lidonit		99.0	13.0	5,0	1,0	1,0	1,0

Table no. 3 *Physico-mechanical properties of aggregates*

No.	Characteristics analyzed	Andesite 4/8 Bicsad	Granite 4/8 Kusser	Lidonit 4/8	UM	CS/2009
1.	Containing granules, MB 08 - Remaining on the sieve higher - Passing through the lower sieve,	5 10	1.5 7,4	1,0 13,0	%	max 5 max 10
2.	Soft granular content, altered, friable, porous and vacuolar MB 10	1,1	0,5	1,5	%	max 5
3.	Resistance to crushing by compression in dry condition, AN 1	78.7	82.32	71.90	%	min 65
4.	coefficient of accelerated grinding, AN 12	1.23	2.23	0.75	-	min 0,50
5.	Quantitative adhesion EB_mCL65	97.32	92.23	90,28	%	min 90
6.	Quantitative adhesion Ralumac	98.53	94.32	91,09	%	min 90
7.	Form coefficient, MB 10	16.6	12.2	15,6	%	max 25

8	Content of impurities: - Foreign, 37 MB - Clay content (VA), AN 07 - Content of fractions less than 0.1 mmAN 01	nu 1,51 1,68	nu 0,82 0,95	nu 0,55 0,66	- % %	not allowed max 2 max 1,5
9	Resistance to freezing - thawing - coefficient of frost cleftness, - sensitivity to frost	1.56 12,3	1.71 10,5	2,01 14.3	%	max 3 max 25
10.	Los Angeles wear, AN 06	16.2	14.4	18.8	%	max 20
11	Resistance to repeated action of Na2SO4,5 cycles, MB 30	1,76	1,12	2,21	%	max 3

Mixed – samples no:

1. Bicsad: C 4/8 – 60 %; NC 0/4 – 40 %; Water 11%; EBmCL65 – 13 %;
2. Kusser: C 4/8 – 40 %; NC 0/4 – 60 %; Water 8 %; EBmCL65 – 12 %;
3. Lidonit 4/8 – 65 % ; NC 0/4 - Bicsad – 35 %; Water 9 %; EBmCL65 – 12 %;
4. Lidonit 4/8 – 60 %; NC 0/4 – Bicsad – 40 %; Water 10 %; EBmCL65 – 12,0;
5. Lidonit 4/8 – 50 %; NC 0/4 – Bicsad – 50 %; Water 10 %; EBmCL65 – 13%;
6. Lidonit 4/8 – 40 %; NC 0/4- Kusser – 60 %; Water 8 %; EBmCL65 – 12 %;

Mixtures were prepared without cement and without additives for controling the breaking of the emulsion.

The 6 types of mixtures were performed with Ralumac emulsion type (12-13) and emulsion EbmCL65 (12-13%).

Table no. 4 *The composition of the mixtures prepared in the laboratory – Ralumac emulsion*

Materials, %	Residual bitumen	Passing the sieve or strainer of... mm, %						
		10,0	8,0	4,0	2,0	1,0	0,63	0,10
Sample 1	7.11	100,0	97,1	62,5	43,1	31.3	27,5	10,8
Sample 2	6.71	100,0	96.0	50.3	35.2	23.4	15.3	6.9
Sample 3	6.79	100,0	99,1	60,8	40.0	25.4	22.5	8.1
Sample 4	6.65	100,0	98.0	67.1	46.1	34.5	29.0	10,7
Sample 5	7.22	100,0	98.5	71.3	49.2	36.5	31.1	11,5
Sample 6	6.68	100,0	97.1	52.5	37.1	22.6	14.1	6.6
Regulatory conditions AND 523/2003-layer running 0/8			**95 - 100**	**50 - 75**	**35 - 55**	**22 - 45**	**12 - 40**	**7 - 15**
Regulatory Conditions 523/2003-layer running AND 0/8			**95 - 100**	**60 – 85**	**35 – 65**	**22 – 50**	**12 – 40**	**7 - 15**

Table no. 5 *The composition of the mixtures prepared in the laboratory – EbmCL65 emulsion*

Materials, %	Residual bitumen	Passing the sieve or strainer of... mm, %						
		10,0	8,00	4,00	2,0	1,0	0,63	0,10
Sample 1	7.21	100,0	98,1	63,1	44,1	30.1	28,1	11,1
Sample 2	6.61	100,0	97.0	51.4	35.5	22.1	16.6	7.2
Sample 3	6.72	100,0	98,1	61,2	39.7	27.8	23.4	8.8
Sample 4	6.75	100,0	98.2	68.1	45.5	35.6	27.5	11,3
Sample 5	7.15	100,0	97.5	72.4	47.1	37.1	32.1	11,9
Sample 6	6.81	100,0	97.7	53.4	35.6	22.5	13.7	7.0
Regulatory conditions AND 523/2003-layer running 0/8			**95 - 100**	**50 - 75**	**35 - 55**	**22 - 45**	**12 - 40**	**7 - 15**
Regulatory Conditions 523/2003-layer running AND 0/8			**95 - 100**	**60 – 85**	**35 – 65**	**22 – 50**	**12 – 40**	**7 - 15**

There are determined the following characteristics of the freshly prepared asphalt mixture:

- mixing time of the mixture of natural aggregate - binder, prewatered water, additive, cement breaking controller at 25 ° C, until the start of hardening (in laboratory);
- mixture composition (fluidity and workability of the mix);
- breaking time of the emulsion - the mixture sample poured to 25°C (in laboratory);
- PH of eliminated water by breaking the emulsion - it is recommended that the eliminated water by breaking the emulsion of the mixture to have an alkaline pH, more than 10.

In the next stage of testing the recipe for the asphalt cold molded, were made samples of mixtures, which after maturation were immersed in water for one hour and subject to abrasion from a test equipment. By using the WTAT test we establish the minimum emulsion necessary and therefore, residual bitumen content in the mixture and the susceptibility to humidity of the bituminous layer. The WTAT test - mass loss in wet abrasion conditions, this test is used to determine the minimum content of bitumen and the tensile strength. Trying sets the minimum acceptable content of emulsion and the susceptibility to moisture of the bituminous layer.

ISSA's standard specifications (International Slurry Surfacing Association) recommend an acceptable mass loss after 1 h immersion in water up to 0.538kg/m2.

Table no. 6 *Values obtained with emulsions - Ralumac emulsion*

Characteristic	UM	Values obtained with emulsion type Ralumac on sample						Allowable values AND 523/2003
		1	2	3	4	5	6	
Mixing time of the mixture at 25 ° C, until the start of hardening (in laboratory)	s	65	125	420	330	200	600	60-180
Mixture composition	cm	2.8	2.2	3.0	2.7	2.6	2.5	2-3
The breaking time of the emulsion - the mixture sample poured to 25°C (in laboratory)	min	10	15	50	40	30	20	15 - 20
Adhesion of the mixture to the substrate *	-	p	p	p	p	p	p	properly
pH of the water removed by breaking the emulsion	min	10,5	10,8	7.5	7.8	7.5	10.9	> 10
The WTAT test - mass loss in wet abrasion conditions: mass loss after 1 h of immersion in water	Km/mp	0.332	0.231	1.557	1.110	0.955	0.957	max 0.538**

* p- properly

** Reference values - ISSA rules (test method ASTM D3910: 1998)

Table no. 7 *Values obtained with emulsions - EbmCL65 emulsion*

Characteristic	UM	Values obtained with emulsion type EbmCL65 on sample						Allowable values AND 523/2003
		1	2	3	4	5	6	
Mixing time of the mixture at 25 ° C, until the start of hardening (in laboratory)	s	60	100	400	310	180	550	60-180
Mixture composition	cm	3.0	2.4	3.2	2.9	2.8	2.7	2-3
The breaking time of the emulsion - the mixture sample poured to 25°C (in laboratory)	min	8	13	45	35	28	18	15 - 20
Adhesion of the mixture to the substrate *	-	p	p	p	p	p	p	properly
pH of the water removed by breaking the emulsion	min	10,1	10,3	6.6	6.7	6.2	9.5	> 10
The WTAT test - mass loss in wet abrasion conditions: mass loss after 1 h of immersion in water	Km/mp	0.456	0.362	1.215	1.090	0.865	1.226	max 0.538**

* p- properly

** Reference values - ISSA rules (test method ASTM D3910: 1998)

Conclusions

Analyzing laboratory results we find that when using lidonit at cold asphalt Slurry-Seal type, the time of emulsion breaking and the eliminating water time from mixture, compared with andesite and granite have increased significantly.

This presents the following advantages:

- Allows reducing the dosage of emulsifier used in preparation of the bituminous emulsion with slow breaking, leading to the increasing of the adhesion of bituminous emulsion to aggregate, thus lowering costs of production of bituminous emulsion;
- Allows elimination of the additive controlling the breaking of bituminous emulsion (delay breaking emulsion) in the process, thus making the work easier and reducing the production costs;
- Enables the utilisation of crushing sand with a sufficient fine part (fraction below 0.10 over 10%),assuring the average grain size required by the curve in AND 523;
- Enables the utilisation of maximum dosage of cement (2%) for breaking time control, which helps to ensure stability cement mixture.
- The fact that the aggregate can be designed even on the average size curve and the use the cement in maximum dosage guarantees the production of a mixture with physical - mechanical characteristics and high performance:

☐ very good workability and homogeneity;
☐ good compactness (if the cast layer needscompaction);
☐high mechanical stability;
☐ insensitivity to water by increasing adhesion of the binder to aggregate and the posibility of lifting the content of residual binder without the risk of excess bitumen apperance on the cast surface, resulting a good behavior at the freeze-thaw.

Disadvantages that may occur as follows:

- Increased costs of production by increasing the dosage of cement.

The optimal recipes obtained in laboratory conditions will support dosages corrections in the execution of experimental sector.

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