ECOLOGICALLY SUSTAINABLE ASPHALT MIXTURES IN THE ROAD TECHNIQUE

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ABSTRACT:

The paper presents the research and experiments realized in order to obtain ecologically sustainable asphalt mixtures. The preparing and laying temperature is lowered with the help of an admixture. The energy consumption is also reduced.

From the ecological point of view, this method reduces the amount of greenhouse gases produced by heating the bitumen and the natural aggregates and in the process of laying the asphalt mixtures.

The preparation of the asphalt mixtures is realized at about 140...155 °C, the laying at 120 °C and the compaction at 90…100 °C.

The experimental section realized on County Road 665 Tg. Jiu (Curtisoara) – Novaci – Baia de Fier – Polovragi, Gorj County, ROMANIA, proves the ecological, technical and economical efficiency of the ecologically sustainable asphalt mixtures.

Key-words: asphalt mixtures, admixtures, eco-sustainable, Iterlow – T, greenhouse gases.

1. PURPOSE OF THE RESEARCH

The significant increase of the road traffic, and especially of the axle load, as well as the urging need for protection of the environment have imposed the necessity for finding new technologies for the asphalt mixtures to be used on the public road network.

In this context, we aimed at obtaining eco-sustainable asphalt mixtures, adapted to the specific road traffic and weather conditions existent in Romania.

In the case of road pavements, the requirements differ depending on the type and role of the road layer within the road structure. These requirements can be grouped as follows:

- requirements related to stability and resistance;
- requirements related to durability in time;
- requirements related to the characteristics of the road surface: evenness, roughness;
- unevenness with consequences on the reduction of greenhouse gases produced by vehicles;
- ecological requirements related to the materials in the composition of asphalt mixtures, such as the noise produced by the road traffic, as well as the effects on the environment;
- road traffic safety requirements during wet weather and reduced visibility (fog and night).

Taking into consideration the present and expected road traffic, the solutions that have been studied and implemented on an experimental public road section, aiming at realizing ecological asphalt mixtures, focused on the following techniques:

- use of natural aggregates resistant to wear;
- addition of a non-reactive polymer (Iterlene) to the mass of bitumen to improve its adhesiveness and of an adequate admixture (Iterlow - T) to reduce the preparation and laying temperatures of the asphalt mixtures during periods with low temperatures;
- processing the asphalt mixtures at low temperatures, leading to positive ecological impact on the environment.

2. GENERAL ASPECTS

The road research is now in a peak period due to the numerous problems encountered by the specialists in the field. As the world is crossing a period of crisis the scientists has to face constantly the lack of necessary funding. This is the reason why the study of the most economically profitable solutions is required. The increase of the traffic speed as well as the increase of the number of vehicles on the roads requires taking measures to ensure traffic safety.

The protection of the environment is an issue that cannot be overlooked anymore; on these issues certain old solutions are being replaced with new, more modern ones. In order to lower the degree of pollution during the manufacturing and lying of asphalt mixtures, the possibility of reducing the working temperatures is researched, aiming at limiting the release of harmful gases. In the meantime, the research is continued regarding the reduction of permanent deformations generated by very intense road traffic, the prevention of thermal or fatigue cracking, the resistance at lower temperatures and to the actions of the chemical solutions used for snow clearing during winter time.

In the case of bituminous pavements, the idea of performance lies in realizing some specific characteristics and their maintenance in time. The basic characteristics of bituminous pavements refer to the surface and the structure. In this context the aims were to achieve the following aspects:

- high quality of road works concerning resistance, sustainability, comfort and safety in operation;
- reduction of expenses for construction and maintenance;
- use of local resources on a large scale by adopting several technical solutions of quality improving;
- observing the ecological requirements concerning the protection of the environment during execution as well as operation periods;
- development of testing methods for the technical solutions in order to determine the application conditions.

The realization of high quality asphalt mixtures required laboratory testing of the components of the mixture (bitumen, aggregate) in order to determine their compliance to the regulations in force.

The present paper insists on researching of methods for testing the behavior in time of the asphalt mixtures. The determination of the asphalt mixture composition aimed at reaching high performance parameters concerning sustainability, safety and comfort in operation and the reduction of greenhouse gases released into the environment.

The relevant properties of the asphalt mixtures related to different performance criteria are an important issue of the research in this field. The performance criteria of asphalt mixtures have been correlated to their physical and mechanical characteristics, which were determine by the laboratory (table 1).

Table 1 - Performance criteria of asphalt mixtures

Performance criteria	Physical and mechanical characteristics of asphalt mixtures
Resistance to permanent deformation	Rheological properties at high temperatures
Resistance to cracking	Thermal susceptibility on short and long term
Resistance of road pavement	Complex modulus
Resistance to thermal cracking	Rheological resistance properties
Fatigue resistance	Resistance to repeated stress
Fabrication and laying	Viscosity at working temperature and stocking stability

3. PROCESSING ECOLOGICAL ASPHALT MIXTURES

The laboratory research, starting from checking of the component materials and ending with checking of the finite product is determinant in realizing adequate works. The realization of ecological asphalt mixtures depends on the optimal selection of the basic materials: bitumen, natural aggregates and admixtures.

In this context, the technology called “warm mixes” for ecological asphalt mixtures was applied with significant economic and environmental benefits.

The WMA (warm mix asphalt) technology especially allows reducing with up to 40 °C the preparing and laying temperatures for asphalt mixtures. It is very economically beneficial due to the low energy consumption and also ecologically beneficial due to the protection of the environment and improvement of working conditions [1].

To this end, a special admixture “Iterlow -T" was used, to ensure the lowering of the preparation and/or laying temperature of asphalt mixtures during the cold season with temperatures under 10 °C.

In order to control the quality and the time behaviour of the mentioned admixture, laboratory research has been conducted and, following the good laboratory results, an experimental section has been realized on County Road CR 665 km 14 to 18, Tg. Jiu - Novaci - Polovragi, Gorj County, Romania. Realization of the asphalt mixtures in the laboratory and their specific technical characteristics is presented as follows.

3.1. Laboratory research

Several dosages have been drawn up for asphalt mixtures using different percentages of bitumen and the Iterlow – T admixture and also their physical and mechanical characteristics have been determined.

The aggregates that were used, their origin and percentage are shown in table 2, and the grading curve is shown in figure 1.

Table 2 – Dosage of B.A. 16a asphalt mixture with Iterlow - T treated bitumen

Element of the asphalt mixture		Origin	% passing through the sieve (square holes. mm)							
Element	**Size**		0.1	0.2	0.63	1	2	4	8	16
Chippings	8-16	Meri quarry	0.0	0.0	0.0	0.0	0.0	0.3	7.5	98.2
Crushed gravel	4-8	Iezureni gravel pit	0.0	0.0	0.0	0.0	0.0	4.2	95.3	100
Crushed sand	0-4	Iezureni gravel pit	2.1	6.2	38.4	59.2	81.7	99.3	100	100
Filler sand	0-4	Iezureni gravel pit	17.3	21.9	39.9	53.7	77.3	95.3	99.9	100
Filler			93.3	99.4	100	100	100	100	100	100
Percentage in the asphalt mixture. %										
Chippings	8-16	29.0	0.0	0.0	0.0	0.0	0.0	0.1	2.2	28.5
Crushed gravel	4-8	27.0	0.0	0.0	0.0	0.0	0.0	1.1	25.7	27.0
Crushed sand	0-4	22.0	0.5	1.4	8.4	13.0	18.0	21.8	22.0	22.0
Filler sand	0-4	14.0	2.4	3.1	5.6	7.5	10.8	13.3	14.0	14.0
Filler		8.0	7.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0
T O T A L		100.0	10.3	12.4	22.0	28.5	36.8	44.4	71.9	99.5
Standard conditions acc. to SR 174-1-2009		min.	8	11	18	22	30	42	66	90
		max.	13	25	35	42	50	66	85	100

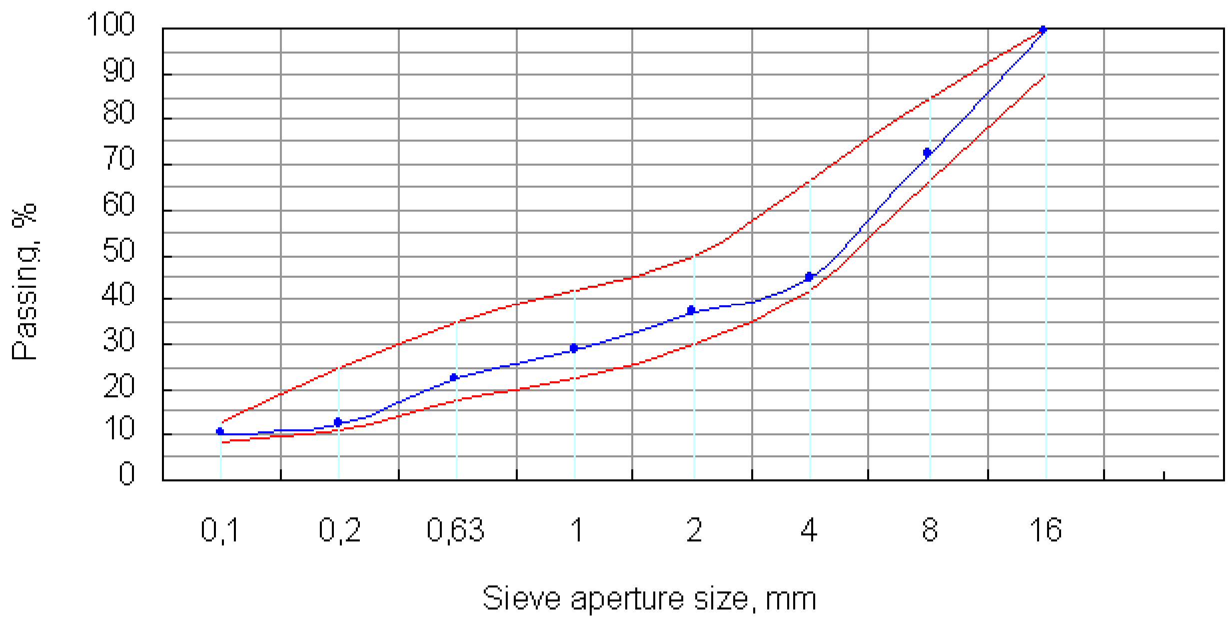


Figure 1 – Grading curve of the aggregate

The grading curve of the aggregate ranges in the grading envelope for B.A. 16 asphalt mixture, according to the Romanian standard SR 174/1-2009.

The realization of a high quality asphalt mixtures means to determine the optimum binder content to ensure the best physical and mechanical characteristics for the asphalt mixture, therefore a good operation behavior. In order to determine the optimum dosage of bitumen, the following relation was used:

$$b = \alpha K \sqrt[5]{S} \quad [\%] \; [2]$$

where: b = bitumen content compared to the mass of aggregate;

α = coefficient depending on the density of the aggregates;

K= content modulus, with values between 3.5...5.0 depending on the type of asphalt mixture;

S = specific surface of the aggregate entering the composition, [m^2/kg].

The following relation was used to calculate the specific surface:

$$100\,S = 0.17A + 0.32\,a + 2.30\,N + 12\,n + 135\,f$$

where : S = specific surface in m^2/kg;

A = percentage of aggregate with size over 8 mm;

a = percentage of aggregate with size between 4 and 8 mm;

N = percentage of coarse sand between 2...4 mm;

n = percentage of sand between 0.1...2 mm;

f = percentage of filler under 0.1 mm.

The asphalt mixtures were prepared in the laboratory (for 5 dosages in different bitumen percentages and with Iterlow – T) and the physical and mechanical characteristics were determined [3].

Table 3 and figure 2 show the physical and mechanical characteristics and the grading curve of the asphalt mixture prepared in the laboratory and laid in order to realize the experimental section.

Table 3 – Physical-mechanical characteristics and grading curve of the asphalt mixture prepared in the laboratory

No.	Characteristic	U.M.	Results	Acc. to SR 174/1-2009
1	Type of asphalt mixture	BA 16a		
2	Bitumen content	%	6.13	6.0...7.3
3	Dry density, min.	kg/m^3	2,408	min. 2,300
4	Water absorption, vol.	%	1.76	1.5...5.0
5	Marshall stability	kN	9.72	min. 6.5
6	Flowing index	mm	2.65	1.5...4.5
7	Stability/Flowing index ratio (S/I)	kN/mm	3.67	1.4...4.3

Grading curve								
Aggregate	% passing through the sieve (square holes, mm)							
	0.1	0.2	0.63	1	2	4	8	16
SR 174/1-2009	8...13	11...25	18...35	22...42	30...50	42...66	66...85	90...100
BA 16a	8.87	12.08	19.05	23.90	32.32	45.30	68.81	98.44

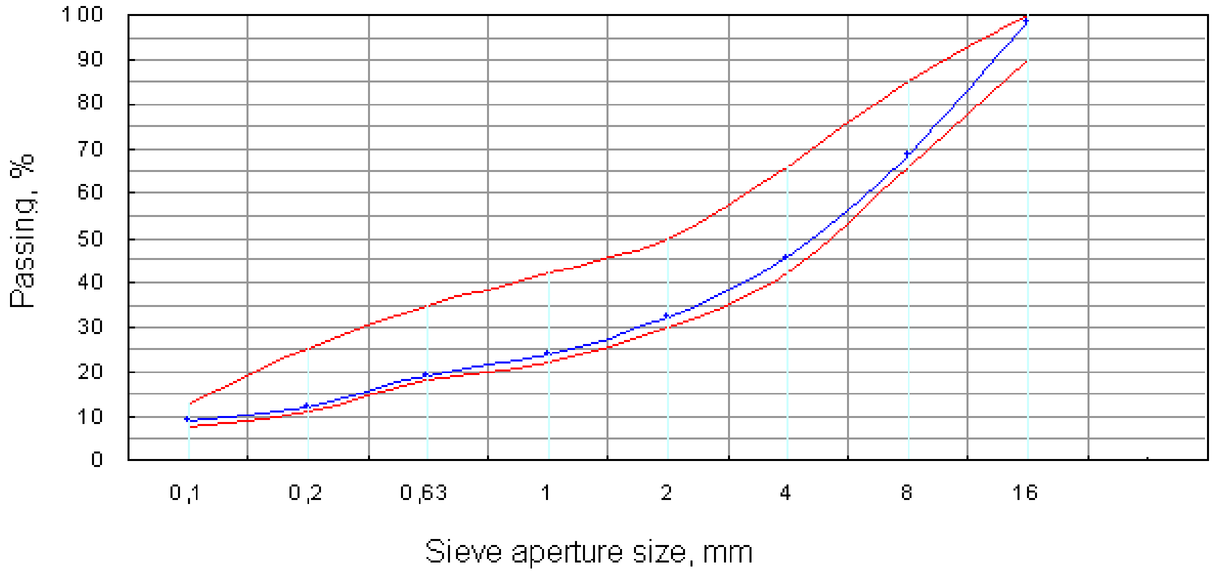


Figure 2 - Grading curve after extracting the bitumen

The grading curve ranges within the grading area of the B.A. 16 type asphalt mixture, and the physical-mechanical characteristics range within the limits stipulated by SR 174/1-2009 [4].

The Iterlow - T type admixture was used in the percentage of 0.36 % of the bitumen.

The used bitumen was D 50/70, with cu 0.2 % Iterlene, to which the Iterlow -T admixture was added in a percentage of 0.36 % of the bitumen.

Laboratory tests have been performed on the bitumen added with the two admixtures in order to determine its physical and mechanical characteristics. The results are shown in table 4.

Table 4 – Characteristics of the bitumen added with 0.36 % Iterlow – T

<table>
<tr><td colspan="2">Determined characteristics</td><td>U.M.</td><td>Results</td><td>Conditions acc.
SR EN 12591 and
SR 174/1-2009</td></tr>
<tr><td colspan="2">Penetration at 25 °C</td><td>1/10 mm</td><td>51</td><td>50...70</td></tr>
<tr><td colspan="2">Ring and ball softening point</td><td>°C</td><td>46</td><td>46...54</td></tr>
<tr><td colspan="2">Fraass breaking point</td><td>°C</td><td>- 10</td><td>max. -8</td></tr>
<tr><td colspan="2">Ductility at 25 °C</td><td>cm</td><td>> 150</td><td>min. 100</td></tr>
<tr><td rowspan="4">Heating stability thin film at 163 °C</td><td>Mass variation</td><td>%</td><td>- 0.04</td><td>max. 0.5</td></tr>
<tr><td>Residual penetration</td><td>%</td><td>63</td><td>min. 50</td></tr>
<tr><td>Softening point after TFOT</td><td>°C</td><td>51</td><td>min. 48</td></tr>
<tr><td>Residual ductility la 25 °C</td><td>cm</td><td>> 150</td><td>min. 50</td></tr>
<tr><td colspan="2">Adhesiveness crushed gravel</td><td>%</td><td>95</td><td>min. 80</td></tr>
</table>

The characteristics of the used added bitumen range in the conditions stipulated by SR EN 12591 [5] and SR 174/1-2009.

An experimental section was realized using the dosage presented above. The performed laboratory tests showed that the used bitumen with two admixtures did not suffer alterations concerning its properties (penetration, viscosity, softening), but its adhesiveness was improved.

The fact that the admixtures do not alter the viscosity of the bitumen, the tension-active action allows the reduction of the internal friction of the coated aggregates, favouring the workability and the movement of the aggregates during compaction even at normal temperatures. Therefore, the asphalt mixtures can be transported long distances, eliminating the logistic issues derived from long distances and the possible difficulties generated by traffic.

4. REALIZATION OF THE EXPERIMENTAL SECTION

The experimental section was realized during the period 29…31 of October 2009, when the environmental temperature was of 6...8 °C. The asphalt mixture was prepared in a plant with discontinued flow with a production capacity of 180 tons/hour. The site is located at about 20 km from the experimental section.

The asphalt mixture was prepared at the temperature of 140...155 °C. The bitumen was D 50/70 added with 0.2 % Iterlene R, to which 0.36 % of the special admixture Iterlow - T was added for cold weather. The supplier's recommendation for the dosage of this admixture was of 0.3...1.0 % of the bitumen, depending on the environmental temperature.

The used natural aggregates and crushed sand were brought from the Meri quarry. The filler was produced in the proper equipment from the processing of the limestone supplied on the site. The river sand was supplied from the proper gravel pit on the Jiu River.

The Iterlow – T admixture is compose of different amine substances, having the appearance of a viscous liquid 25 °C, with the density of 1.0 g/cm^3, at the temperature of 25 °C. The admixture was supplied in 200 kg barrels and it is stable at environmental temperatures and stored in covered enclosures. The sensitivity of the admixture is lower at low temperatures, which allows its medium and low term storing. The admixture, instantaneous, allows the processing of the asphalt mixtures at temperatures of 140...155 °C and, consequently, their laying at temperatures of about 120 °C.

On the experimental section, the asphalt mixtures were spread at the temperature of 120 °C, and compacted at 90...100 °C, using a 40 kN compactor and a 120 kN vibration compactor. Aspects from the realization of the experimental section are shown in figures 3 and 4.

Figure 3 – Laying of the asphalt mixture; measuring the temperature of the asphalt mixture before laying and compacting.

Figure 4 – Compaction equipment

At the laying point, a significant decrease of aromatic emissions was noted in comparison the spreading of traditional asphalt mixtures. A good workability during spreading of the asphalt mixtures was also found during compaction (figure 5).

Figure 5 – Aspect of the realized experimental section

Samples of asphalt mixture were taken from the laying area and the physical-mechanical characteristics of the asphalt mixture and the grading curve of the aggregate obtained after extracting the bitumen are shown in table 5 and figure 6.

Table 5 – Physical-mechanical characteristics and grading curve of the sampled asphalt mixture

No.	Characteristic	U.M.	Results	Acc. to SR 174/1-2009
1	Type of asphalt mixture	B.A. 16a		
2	Bitumen content	%	5.6	6.0...7.3
3	Dry density	kg/m^3	2,410	min. 2,300
4	Water absorption	%	1.0	1.5...5.0
5	Marshall stability. S	kN	12.3	min. 6.5
6	Flowing index. I	mm	4.7	1.5...4.5
7	S/I ratio	kN/mm	2.5	1.4...4.3
8	Rigidity modulus determined by indirect stress	MPa	8,747	min. 4,500

Grading curve								
Aggregate	% passing through the sieve (square holes. mm)							
	0.1	0.2	0.63	1	2	4	8	16
SR 174/1-2009;	8...13	11...25	18...35	22...42	30...50	42...66	66...85	90...100
BA 16a	4.9	7.6	17.8	22.8	30.4	39.4	61.8	95.0

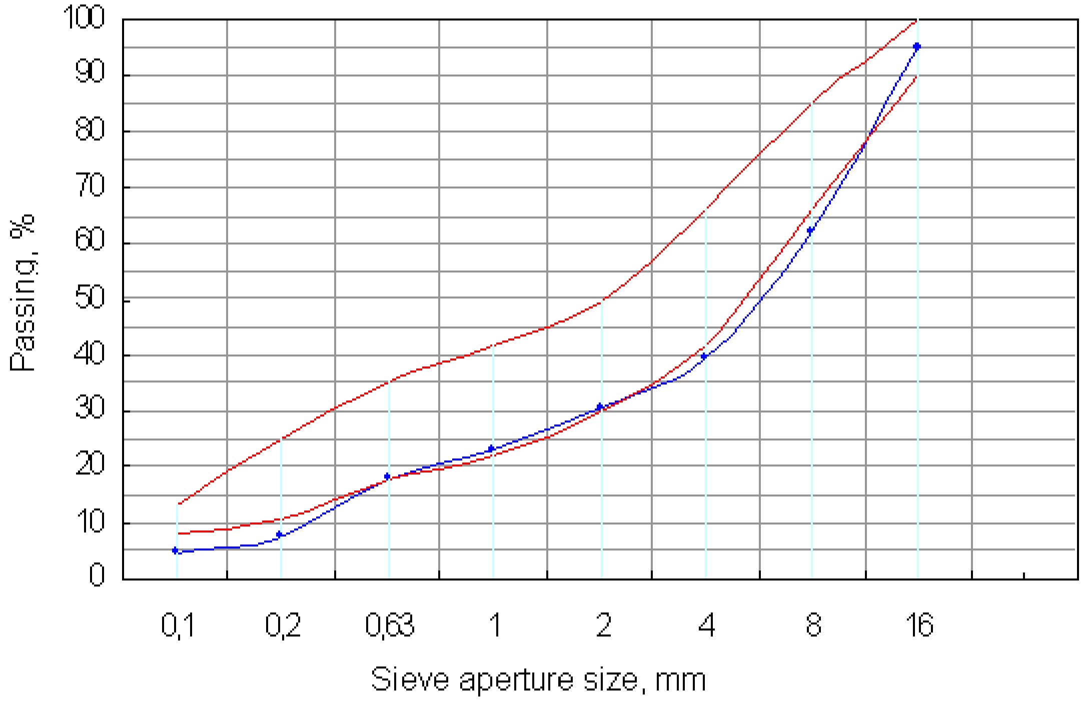


Figure 6 – Grading curve of aggregate after extracting the bitumen

The analysis of table 5 and figure 6 shows the following aspects:

- Bitumen content: 5.6 %, lower than the one determined in the laboratory and stipulated by SR 174/1-2009;
- Dry density: 2,410 kg/m^3, much higher compared to SR 174/1-2009;
- Marshall stability, with a value of 12.3 kN, shown a good behavior of asphalt mixtures under heavy traffic and at high temperatures;
- Rigidity modulus with a value of 8,747 MPa shows a good behavior at low temperatures;
- Water absorption and flowing index are close to the conditions imposed by the standards;
- Grading curve shows a lower percentage of fines compared to SR 174/1-2009, without impairing on the physical-mechanical characteristics of the asphalt mixtures.

The bitumen content is correlated to the content of fines; the content of fines being lower, the specific surface of the aggregates is smaller leading to a lower bitumen content. Therefore, the characteristics of the asphalt mixtures did not influence their operation behavior.

During exploitation, bitumen ages, by evaporation of constituent oils through oxidation and polymerization. Bitumen changes its properties, becomes harder and harder until it is began to be fragile and breakable.

Performed laboratory tests aimed at bitumen ageing using the RTFOT method (Rolling Thin Film Oven Test Method) and also the PAV method (Pressure Asphalt Vessel) [6].

The fact that, in the process of asphalt mixture preparation a special additive, Iterlow-T, is used, it permitted to reduce the temperature of the bitumen having positive effects such as the increase of the exploitation lifetime by 2 or 3 years.

To determine the compatibility of the additive to the bitumen the coefficient of colloidal instability was calculated as the ratio of saturated asphaltene to aromatic and resins amount, the result being 0.15. The Romanian standards are requiring having this coefficient less than 0.5, so the result complies.

5. OPERATION BEHAVIOR OF THE EXPERIMENTAL SECTION

The experimental section was observed for nearly a year and its behavior was good. After almost a year from its realization, in September 2010, samples were taken from the bituminous pavement. Aspects are shown in figures 7 and 8.

Figure 7 – Aspects of the experimental section

Figure 8 – The experimental section after one year of operation

Samples were taken with the 200 mm diameter equipment, figure 9.

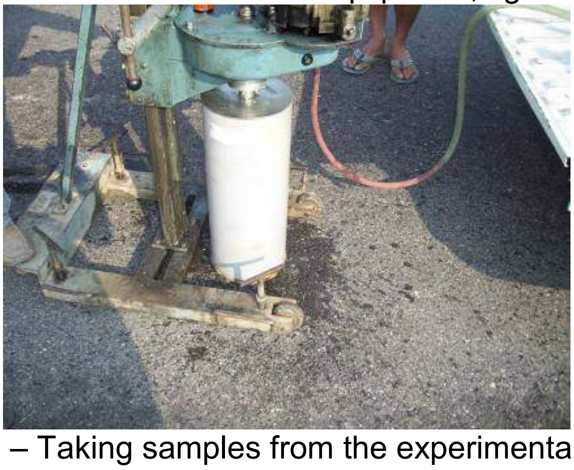


Figure 9 – Taking samples from the experimental section

The samples of asphalt mixture taken from the experimental section were analyzed in the site laboratory at Iezureni and in the road laboratories at the “Politehnica” University of Timisoara (U.P.T.) and D.R.D.P. Timisoara, Romania. The results are shown in table 6.

Table 6 - Physical and mechanical characteristics and grading curve of the asphalt mixture

<table>
<tr><th>No.</th><th colspan="4">Characteristic</th><th>U.M.</th><th>Results</th><th colspan="2">Acc. to SR 174/1-2009</th></tr>
<tr><td>1</td><td colspan="4">Type of asphalt mixture</td><td colspan="4">BA 16a</td></tr>
<tr><td>2</td><td colspan="4">Bitumen content</td><td>%</td><td>5.6</td><td colspan="2">6.0...7.3</td></tr>
<tr><td>3</td><td colspan="4">Dry density. min.</td><td>kg/m³</td><td>2,325</td><td colspan="2">min. 2,300</td></tr>
<tr><td>4</td><td colspan="4">Dry density on plates. min.</td><td>kg/m³</td><td>2,334</td><td colspan="2">min. 2,300</td></tr>
<tr><td>5</td><td colspan="4">Water absorption. vol.</td><td>%</td><td>4.1</td><td colspan="2">1.5...5.0</td></tr>
<tr><td>6</td><td colspan="4">Marshall stability</td><td>kN</td><td>10.7</td><td colspan="2">min. 6.5</td></tr>
<tr><td>7</td><td colspan="4">Flowing index</td><td>mm</td><td>3.6</td><td colspan="2">1.5...4.5</td></tr>
<tr><td>8</td><td colspan="4">Stability/Flowing index ratio (S/I)</td><td>kN/mm</td><td>3.0</td><td colspan="2">1.4...4.3</td></tr>
<tr><td>9</td><td colspan="4">Rigidity modulus at 15 °C. minimum</td><td>MPa</td><td>9,258</td><td colspan="2">4,500</td></tr>
<tr><td>10</td><td colspan="4">Compaction degree. minimum</td><td>%</td><td>100</td><td colspan="2">96</td></tr>
<tr><td>11</td><td colspan="4">Dynamic flow
- Resistance to permanent deformation:
- Deformation at 50 °C. 300 kPa and 1800 impulses maxim;</td><td>µm/m</td><td>14,207</td><td colspan="2">30,000</td></tr>
<tr><td colspan="9">Grading curve</td></tr>
<tr><td rowspan="2">Aggregate</td><td colspan="8">% passing through sieves (square holes. mm)</td></tr>
<tr><td>0.1</td><td>0.2</td><td>0.63</td><td>1</td><td>2</td><td>4</td><td>8</td><td>16</td></tr>
<tr><td>SR 174/1-2009;</td><td>8...13</td><td>11...25</td><td>18...35</td><td>22...42</td><td>30...50</td><td>42...66</td><td>66...85</td><td>90...100</td></tr>
<tr><td>BA 16a</td><td>6.3</td><td>8.6</td><td>20.2</td><td>27.5</td><td>37.5</td><td>49.0</td><td>77.2</td><td>98.5</td></tr>
</table>

- Bitumen content: 5.6 %, lower than the one determined in the laboratory and stipulated by SR 174/1-2009;
- Dry density determined on Marshall cylinders is 2,325 kg/m^3, and dry density determined on samples taken from the bituminous pavement is 2,334 kg/m^3, ranges within the technical conditions stipulated by SR 174/1-2009;
- Marshall stability, the load at the moment when the sample breaks has a value of 10.7 kN (figure 10), shows a good behavior of asphalt mixtures under heavy traffic and at high temperatures;
- Flowing index, deformation of the asphalt mixture in the moment of sample breaking is 3.6 mm and meets the requirements imposed by the standard in force;
- Rigidity modulus (figure 11) with a value of 9,258 MPa, shows a good behavior of the asphalt mixtures at low temperatures;
- Resistance at permanent deformation at 50 °C, having a value of 14,207 µm/m, much lower than stipulated by SR 174/1-2009, shows a good behavior in operation at high temperatures;
- Water absorption of 4.1 % ranges within the technical conditions stipulated by SR 174/1-2009;
- Grading curve shows a lower percentage of fines compared to the one stipulated by SR 174/1-2009, without altering the physical and mechanical characteristics of the asphalt mixtures.

The supporting layer of the ecologically sustainable asphalt mixture is composed of an binder type asphaltic mixture having a high bitumen content, i.e. 4.1 % and natural aggregates such sorted crushed gravel. The thickness of the support layer is 5 cm.

In conclusion, the asphalt mixture has a good operation behavior.

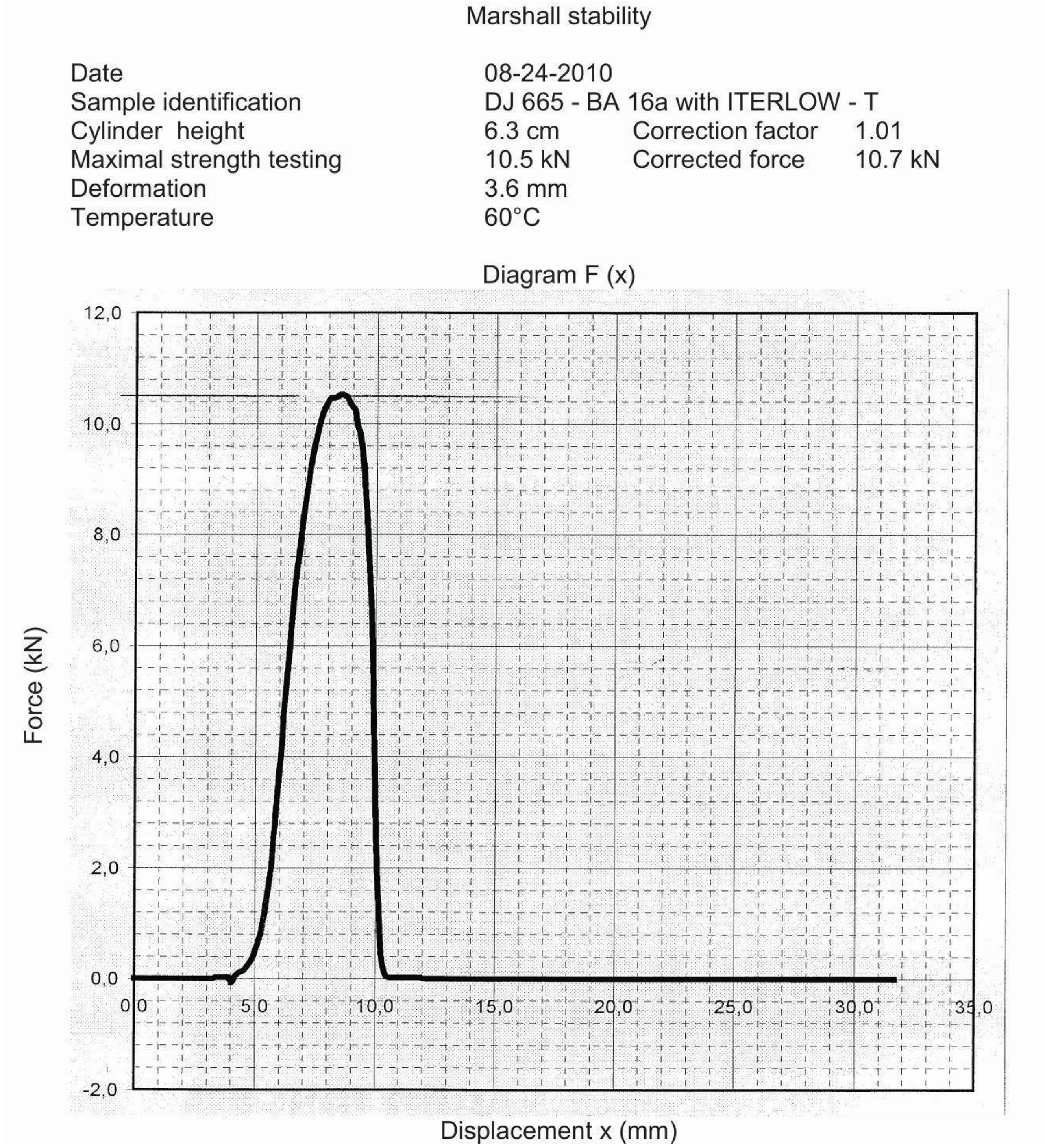


Figure 10 - Marshall stability

INDIRECT TENSILE STIFFNESS MODULUS TEST REPORT. Serial No.

(Stiffness modulus test to EN 12697-26:2004(E): Test carried out on NU-14)

<u>Testing Laboratory Address</u>

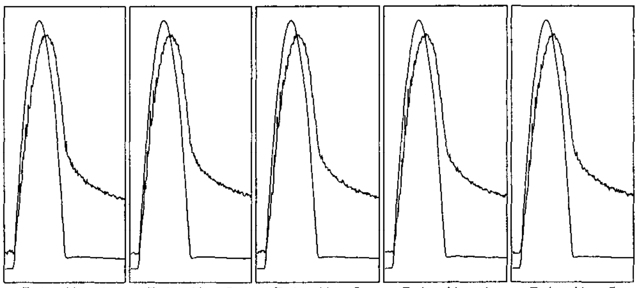
Date: 31:08:2010

Specimen ref: DJ 665 - BA16a cu ITERLOW-T
Test temperature: 15°C
Specimen diameter: 100 mms
Specimen thickness: 61 mms
Poisson's ratio: 0,35
Target risetime: 124 m.secs
Target horiz defm: 5 microns

Date of issue:	aug312010	Client:	

Type & origin of bituminous mixture	
Method of manufacture of the bituminous mixture	
Method of compaction	
Bulk density: 2325,000(gm/cml). Determined by method:	

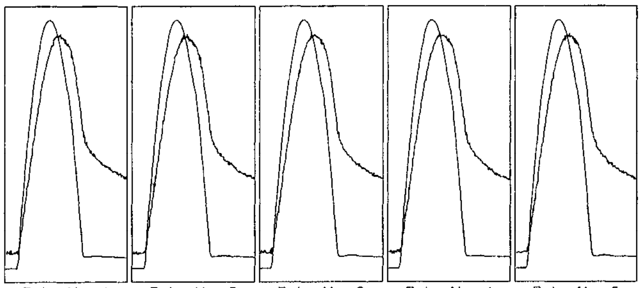
<u>First test</u>



Pulse No. 1 Pulse No. 2 Pulse No. 3 Pulse No. 4 Pulse No. 5

Pulse No.	Vertical force (kN)	Horiz Stress (kPa)	Load area factor		Horiz defm (microns)		Rise Time (m.secs)		Stiffness modulus (MPa) 1st diameter	
			Target	Actual	Target	Actual	Target	Actual	Measured	Adjusted
1	4,51	471,2	0.60	0,64	5,0	4,8	124	84,0	9501	9790
2	4,51	471,1	0.60	0,65	5,0	5,0	124	85,0	9243	9582
3	4,51	471,2	0.60	0,65	5,0	4,9	124	85,0	9294	9634
4	4,51	471,1	0.60	0,65	5,0	5,0	124	85,0	9237	9574
5	4,52	471,3	0.60	0,65	5,0	5,0	124	85,0	9241	9575
Mean	**4,51**	**471,2**	**0.60**	**0,65**	**5,0**	**4,9**	**124**	**84,8**	**9303**	**9631**

<u>Second test</u>



Pulse No. 1 Pulse No. 2 Pulse No. 3 Pulse No. 4 Pulse No. 5

Pulse No.	Vertical force (kN)	Horiz Stress (kPa)	Load area factor		Horiz defm (microns)		Rise Time (m.secs)		Stiffness modulus (MPa) 2nd diameter	
			Target	Actual	Target	Actual	Target	Actual	Measured	Adjusted
1	4,22	440,1	0.60	0,64	5,0	5,0	124	105,0	8613	8880
2	4,22	439,9	0.60	0,65	5,0	5,1	124	107,0	8478	8789
3	4,22	440,4	0.60	0,65	5,0	5,0	124	105,0	8589	8882
4	4,22	440,6	0.60	0,66	5,0	4,9	124	107,0	8688	9024
5	4,22	440,7	0.60	0,65	5,0	5,0	124	105,0	8555	8849
Mean	**4,22**	**440,3**	**0.60**	**0,65**	**5,0**	**5,0**	**124**	**105,8**	**8584**	**8885**

<u>Mean of two tests</u>

Load (rise) time (ms) : 95,3
Horizontal deformation (µm) : 5,0
Measured stiffness modulus (MPa) : 8944
Adjusted stiffness modulus (MPa) : 9258

Figure 11 – Rigidity modulus

6. CONCLUSIONS AND RECOMMENDATIONS

The results obtained on asphalt mixtures prepared with admixtures for cold weather form an answer to the possibility of extending the laying period of asphalt mixtures with benefits for the environment and the workers who prepare and lay the mixtures (reduced smoke and aromatic emissions).

The research and studies performed on this type of asphalt mixtures with admixtures for cold weather resulted in the following conclusions:

- the preparation of eco-sustainable asphalt mixtures allows the lowering with about 30...40 °C of the preparation temperature, inferior to the classical asphalt mixtures due to the increase of workability;
- the processing of asphalt mixtures is realized at temperatures of 140...150 °C, and the compaction at 90...100 °C.

Analyzing the fuel and energy consumption data, it became clear that using the additive Iterlow–T, thus significantly reducing the temperature for preparing, laying and compacting of the asphalt an important economy in fuel and energy appears and also the amount of greenhouse gases lowers. By reducing the temperature of the asphalt mixture by 30...40 °C the energy consumption is reduced approx. by 30 %, representing approx. 12 kWh/tone of asphalting mixture. The Italian Bernardi asphalt station, having a capacity of 180 to/hour, the fuel consumption is approx 9 litres for 1 tone preparing asphalt mixture.

A lower temperature in the production process assures a lower greenhouse gases emission and also air pollutants. Our approximations on the field resulted that, for lowering the temperature by 30 °C greenhouse gases emission is reduced by approx. 65 %.
International experience [7] is showing that emissions in WMA production stations are significantly reduced:

- CO_2 emissions are 30...40 % reduced;
- SO_2 emissions are 20...35 % reduced;
- VOC (volatile organic compounds) emissions are 50 % reduced;
- CO emissions are 10...30 % reduced;
- NOx emissions are 60...70 % reduced.

Furthermore,

- the used Iterlow – T admixture does not modify the physical and mechanical characteristics of the bitumen: penetration, softening point, viscosity;
- the Iterlow – T admixture, by its tension-active properties, reduces the internal friction among the bitumen coated grains, thus increasing the workability of the mixture;
- the asphalt mixtures can be transported on longer distances (50...60 km);
- important fuel economy can be realized when heating the aggregates, the bitumen and when preparing the mixtures by:
    - reducing work temperatures (by 30...40 °C);
    - reducing mixing temperature by 30 °C;
    - reducing energy consumption by approx. 30 %;
- the phenomenon of ageing of the bitumen is eliminated by lowering the preparation temperatures; the ageing phenomenon leads to unfortunate consequences in the behaviour of bituminous pavements, reducing their life span and ultimately to increasing costs in maintaining the road sector;
- the environment is protected and the quality of life of the inhabitants and the workers in the field is improved by:

• reducing the effects of bitumen aging;
• reducing laying temperatures;
• reducing the emissions of greenhouse gases in the atmosphere by 20...30 %;
• reducing the workers' exposing degree to toxic emissions conditions by 10...15 %;
• reducing the noxious effect on the local residents;

- the Iterlow – T admixtures favours the preparation and laying of asphalt mixtures at environmental temperatures under 10 °C, in comparison with those stipulated by the standards in force, which are over 10 °C, thus increasing the interval of laying the asphalt mixtures, and therefore the rehabilitation of more kilometres of road.

In conclusion, it is worth mentioning that through research we can obtain eco-sustainable asphalt mixtures, beneficial for those working in the road field, as well as for the environment, the residents and all the users of public roads.

As a general conclusion, we can state that the researched and tested asphalt mixture is beneficial both from the economical and environmental point of view; it improves the life quality of both the workers and the inhabitants of the area; it shows beneficial technical effects since works can be performed at temperatures below 10 °C in order to cover the layers of open asphalt mixture during winter.

The technology to realize the ecologically sustainable asphalt mixtures for local roads having low and medium traffic has been applied for the first time in our country in 2009, as it was a brand new technology at that time.

REFERENCES

1. Rühl, R. Lower temperatures – The best for asphalt, bitumen, environment and health and safety; Proceedings of the 4th Eurasphalt & Eurobitume Congress, Copenhagen 2008; paper 500-013.
2. Lucaci, G., Costescu, I., Belc, F. (2000). Constructia drumurilor (Road construction), pp 281-285.
3. Nicoara, L., et al. Indrumator pentru laboratoarele de drumuri (Guide for road laboratories) (1998), pp 197 - 223.
4. XXX SR 174/1-2009. Îmbrăcăminţi bituminoase cilindrate executate la cald. (Hot rolled bituminous pavements).
5. XXX SR EN 12591. Bitum si lianti bituminosi. Specificatii pentru bitumuri rutiere. (Bitumen and bituminous binders. Specifications for road bitumen).
6. Romanescu, C. Racanel, C. (2003) Reollogia liantilor bituminosi si a mixturilor asfaltice pp 215-219.
7. WARM – Mix Asphalt: European Practice; International technology Scanning Program, pp 9-11. February 2008.