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THE USE OF ASPHALT MIXTURES IN ROAD STRUCTURES

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Rezumat. *Lucrarea prezintă testele efectuate pe 4 rețete de mixtură bituminoasă BA 16 rul 50/70 cu înlocuirea parțială a agregatelor naturale cu agregate artificiale de zgură (respectiv inlocuirea cu 25% zgură de aluminiu din cantitatea totală de nisip) și alte 2 rețete cu înlocuirea bitumului cu un bitum aditivat comparativ cu o rețetă clasică în care au fost utilizate agregate 100% naturale si bitum neaditivat. Testele utilizate au fost alese pentru a caracteriza caracteristicile fizico-mecanice ale aceleeași retete de mixtură cu înlocuirea parțială a diverselor componente. Rezultatele indică faptul că amestecul de mixtură cu agregate de zgură poate fi o resursă valoroasă în proiectarea amestecurilor de asfalt și s-au obținut performanțe satisfăcătoare care respectă cerințele din normativele naționale.*

Abstract. *The paper presents the tests performed on 4 bituminous mixture recipes, BA 16 rul 50/70, with partial replacement of natural aggregates with artificial slag aggregates (respectively replacement with 25% aluminum slag from the total amount of sand) and other 2 recipes with replacement of bitumen with an additive bitumen compared to a classic recipe in which aggregates were used 100 % natural and without additives bitumen. The tests used were chosen to characterize the physical-mechanical characteristics of the same mixture recipe with the partial replacement of various components. The results indicate that the mixture of asphalt with slag aggregates can be a valuable resource in the design of asphalt mixtures and satisfactory performance has been achieved that meet the requirements within national regulations.*

Keywords: Bituminous mixture, slag, bitumen, additives

1. Introduction

Natural quarry aggregates are natural resources of the environment that cannot be regenerated and considering the expansion of the road network it becomes imperative to look for alternative solutions for the production of high performance asphalt mixtures to meet the conditions imposed by technical standards and regulations.

The asphalt mixing recipes with natural or artificial aggregates, have to be tested and to comply with the actual technical regulations, respectively the standard SR EN 13043:2003, SR EN 13043:2003/AC:2004 and AND 605/2016 „*Standard on*

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the execution of hot asphalt mixes. Technical requirements for the design, preparation and implementation work."[5], [6].

The wear layer is the layer directly subjected to the loads transmitted by the car tires and the asphalt mixtures used for this layer must ensure resistance, durability as well as a tread with a good adhesion to the car tires.

Thus, there are several international studies on recipes obtained with slag in which conventional aggregates have been replaced with slag and the results have been satisfactory [1], [3], [3], [4].

2. Experimental study

2.1. Used materials

This experimental study was performed in the INCERTRANS laboratory on the mixture BA 16 rul 50/70, designed by the Marshall method and the 4 different types of mixing recipes with partial replacement of natural aggregates with artificial slag aggregates (respectively replacement with 25% aluminum slag from the total amount of sand) and other 2 recipes with replacement of bitumen with an additive bitumen compared to a classic recipe in which aggregates were used 100 % natural and without additives bitumen.

The percentages of recipe BA 16 rul 50/70 are those in Table 1.

The natural aggregates used (sorts 0-4, 4-8, 8-16) were quarry aggregates.

The crushed artificial aggregates (granularity class 0-2 mm) used in this study came from aluminum slag and the other materials used were filler and bitumen D50 /70 pen.

Table 1) Recipe BA 16 rul 50/70

Material used	Percentage [%]	
	Quarry aggregates	With aluminum slag
granularity class 8-16 mm	28	28
granularity class 4-8 mm	23	23
granularity class 0-4 mm	40	32
Slag granularity class 0-2 mm	-	8
Filler	9	9
Bitumen 50/70 pen	5,7	5,7

Table 2) Asphalt mixture recipe variants

Recipe variant	Natural aggregates, granularity class	Aluminum slag aggregates, granularity class	Bitumen Type
A (reference)	0-4, 4-8, 8-16 mm	-	D50/70 without additives
B	0-4, 4-8, 8-16 mm	0-2 mm	D50/70 without additives
C	0-4, 4-8, 8-16 mm	-	D50/70 with 0,3% Adeten Red 30
D	0-4, 4-8, 8-16 mm	-	D50/70 with 0,2% Poliadfo

The grading curve for asphalt mixture meets EN 13108 as well as the Romanian standard requirements AND 605/2016.

2.2. Samples preparation

The specimens were compacted in laboratory depending on performed tests. Thus, were manufactured cylindrical samples at Marshall Hammer for 50 blows compacting energy per side [8], [9], [10], [11], 12]. Samples preparation and mixing were according to SR EN 12697-35.

2.3. Results

Following the above laboratory tests on cylindrical samples on the four types of BA 16 rul 50/70 asphalt mixtures (A, B, C, D) the experimental results represented in Figures 1…9, were obtained to emphasize the influence of the slag and of the bitumen type (without additives and with 0,3 % Adeten Red 30 and with 0,2 % Poliadfo) in asphalt mixture.

Figures 1 to 9 show the results obtained from the tests presented in chapter 2 according to the standard EN 13108-1 as well as within the limits imposed by the AND 605-2016 norm [7]:

- Bulk density represented for the 4 mixtures - Figure 1;
- The Marshall stability and index flow represented for the 4 mixtures - Figures 2 and 3;
- Volume of voids at 80 rotations represented for the 4 mixtures – Figure 4;
- Percentage of volume of voids in the VMA mineral skeleton represented for the 4 mixtures - Figure 5;

- Percentage of voids volume in the mineral skeleton filled with binder VFB represented for the 4 mixtures - Figure 6;
- Resistance to permanent deformations (dynamic creep) - deformation at 50^0 C, 300 KPa and 10,000 pulses represented for the 4 mixtures – Figure 7;
- Deformation speed at 50^0 C, 300 KPa and 10.000 pulses represented for the 4 mixtures – Figure 8;
- Stiffness mode at 20^0 C, 124 ms represented for the 4 mixtures – Figure 9.

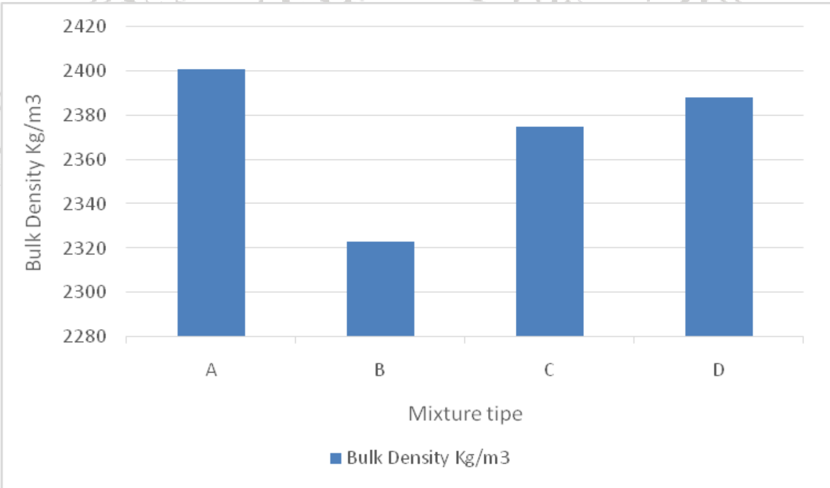

Fig. 1. Bulk density of asphalt mixture.

It appears from Fig. 1 that the values of bulk density obtained for mixture with natural aggregate is higher than that obtained for the blast furnace slag mixture. The result is explained by the fact that the density of the slag is lower than that of the quarry aggregates.

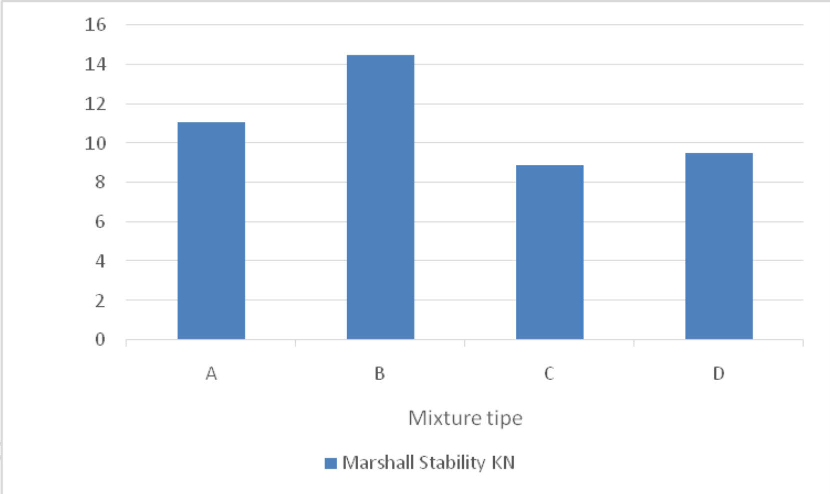

Fig. 2. The Marshall stability represented for the 4 mixtures.

All 4 recipes gave good value to the Marshall Stability test, the best value is 14.5 KN at the receip B with aluminum slag which means that it can be used with excellent results in mixing recipes. All 4 recipes fall within the requirements imposed by the actual regulation, minimum of 6.5 KN and maximum 13.0 KN respectively.

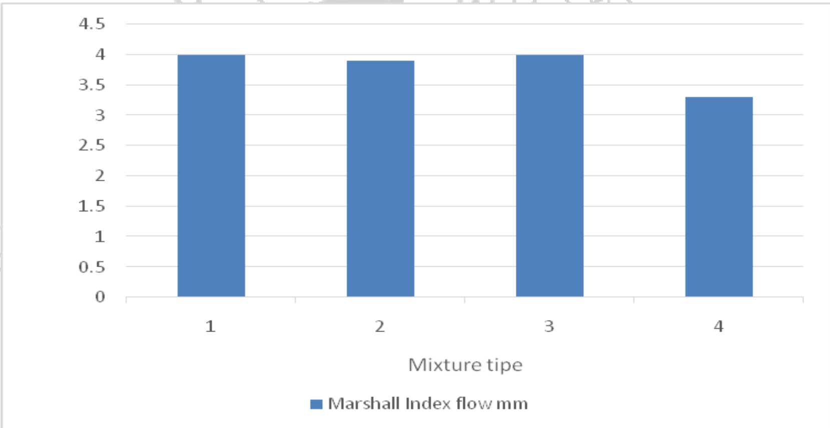

Fig. 3. Marshall Index flow of asphalt mixture.

The results indicate satisfactory results of the Marshall index flow in all four recipes. The values were in the required minimum of 1,5 mm and maximum 4,0 mm.

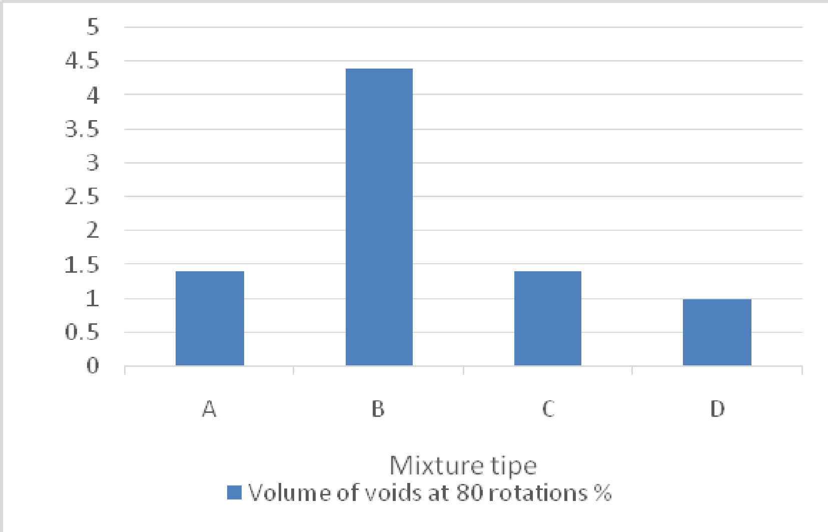

Fig. 4. Volume of voids at 80 rotations of asphalt mixture.

The volume of voids at 80 rotations is in the condition imposed by a maximum value of 5% for all 4 types of mixture. The best value (1%) was observed in recipe D with POLIFADO additive bitumen compared to the value of 4.4% in the recipe with replacement with 25% aluminum slag from the total amount of sand.

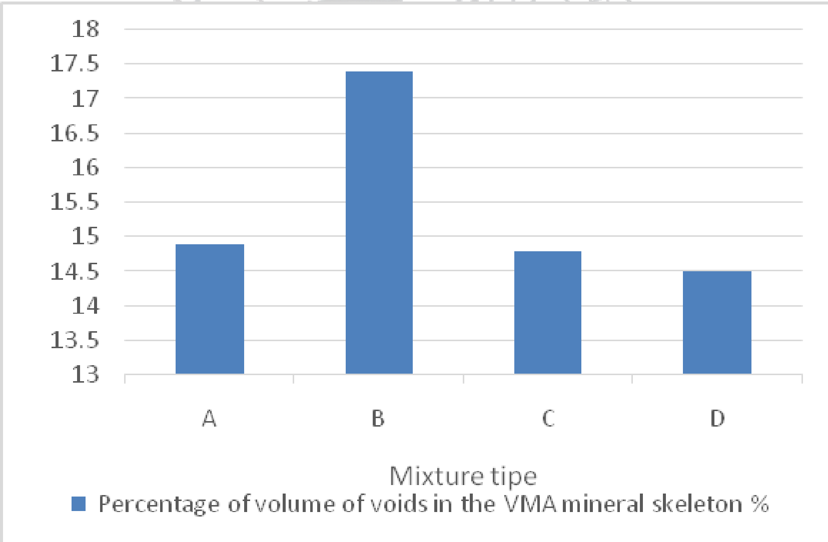

Fig. 5. Percentage of volume of voids in the VMA mineral skeleton represented for the four mixtures

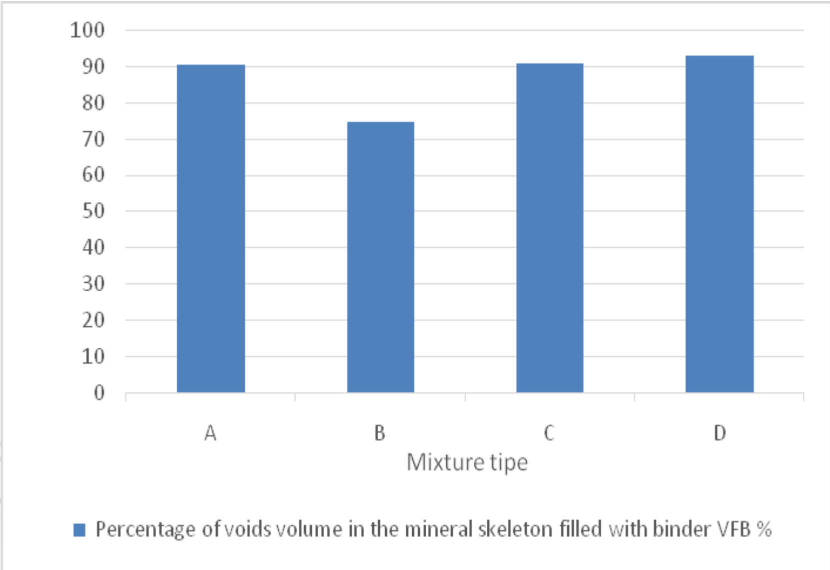

Fig. 6. Percentage of volume of voids in the mineral skeleton filled with binder VFB.

The best values in terms of the percentage of the volume of voids in the VMA mineral skeleton but also the percentage of the volume of voids in the mineral skeleton filled with VFB binder had the mixing recipes with additive bitumen and recipe D had the best values.

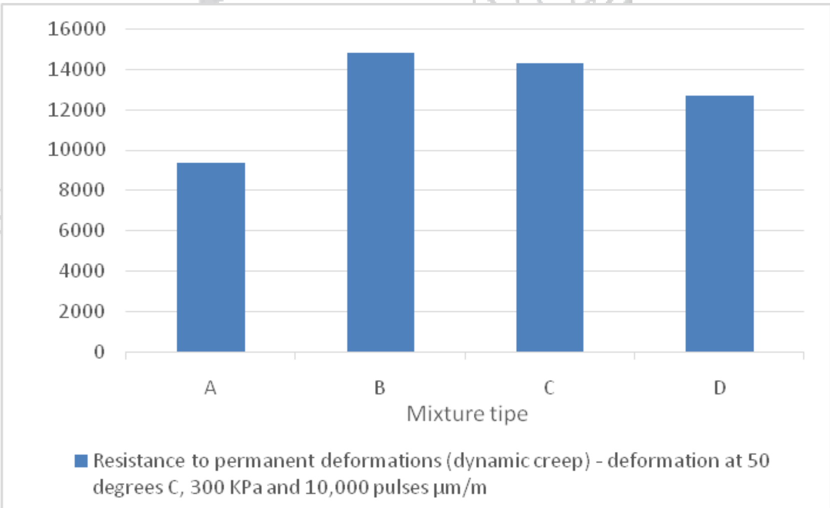

Fig. 7. Resistance to permanent deformations (dynamic creep) - deformation at 50^{0}C, 300 KPa and 10,000 pulses.

The best values in terms of resistance to permanent deformations (dynamic creep) - deformation at 50^{0}C, 300 KPa and 10.000 pulses had recipe A. The all values were in the required maximum 20.000 µm/m.

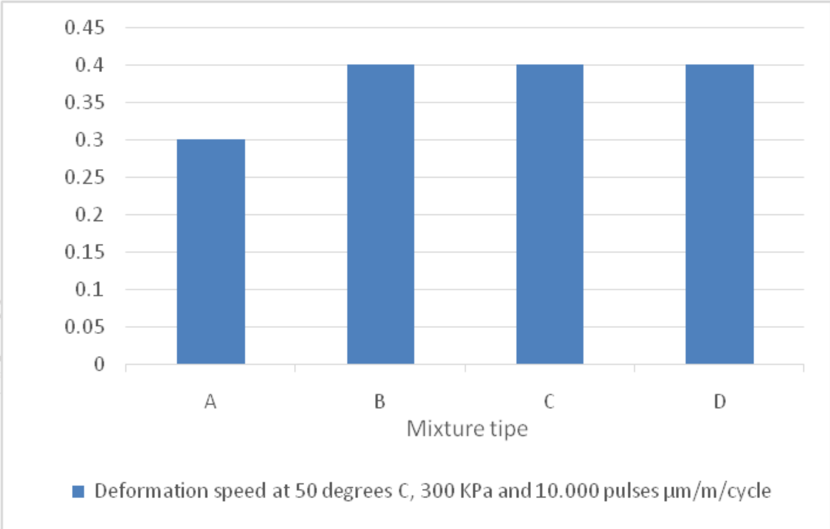

Fig. 8. Deformation speed at 50^{0}C, 300 KPa and 10.000 pulses.

The results indicate satisfactory results of the deformation speed at 50^{0}C, 300 KPa and 10.000 pulses in all four recipes. The values were in the required maximum 1,0 µm/m/cycle.

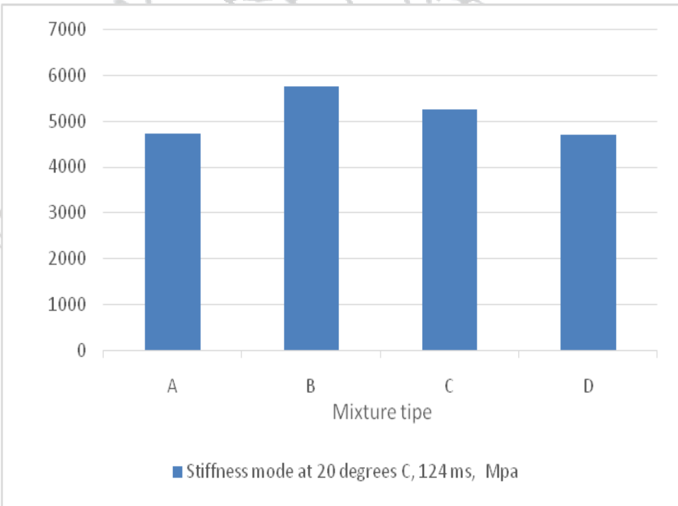

Fig. 9. Stiffness mode at 20^{0}C, 124 ms.

The best values in terms of stiffness mod had recipe *B*. The all values were in the required minimum of 4.200 KPa.

Conclusions

The use of slag asphalt mixes has several important advantages for environmental protection, thus reducing existing slag deposits in our country and saving local resources.

As is known, hot mix asphalt is a building material made by a process involving the heating of natural aggregates and bitumen, mixing of the mixture, transport and putting into operation by hot compaction [AND 605-2016].

To produce asphalt mixtures, a wide variety of mineral aggregates are used both natural and from unconventional (artificial) sources.

The values of density obtained for mixture with natural aggregate is higher than that obtained for the blast furnace slag mixture.

All 4 recipes gave good value to the Marshall Stability test, the best value is 14.5 KN at the recipe B with aluminum slag which means that it can be used with excellent results in mixing recipes. All 4 recipes fall within the requirements imposed by the actual regulation, minimum of 6.5 KN and maximum 13.0 KN, respectively.

The results indicate satisfactory results of the Marshall index flow in all four recipes. The values were in the required minimum of 1,5 mm and maximum 4,0 mm.

The volume of voids at 80 rotations is in the condition imposed by a maximum value of 5 % for all 4 types of mixture. The best value (1%) was observed in recipe D with POLIFADO additive bitumen compared to the value of 4.4% in the recipe with replacement with 25% aluminum slag from the total amount of sand.

In the future, it is necessary to study other percentages of replacement of natural aggregates with slag but also the use of additive bitumen in the slag mixing recipe which may lead to a better conclusion, on the percentage of volume of voids in the mineral skeleton filled with VFB binder, in the mixture of asphalt with slag.

R E F E R E N C E S

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