EXPERIMENTAL STUDIES ON BITUMINOUS MIXTURES REINFORCED WITH FIBERGLASS

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Rezumat. *Lucrarea isi propune demonstrarea acțiunii armării mixturii asfaltice cu fibră de sticlă asupra rezistenței la fisurare. Prin incercari de laborator se va verifica efectul armării cu fibre de sticlă a mixturilor asfaltice asupra deformațiilor sub încărcare ciclică, comparativ cu una nearmată. Inițierea fisurilor și propagarea acestora sunt cauzate de tensiunile de întindere, care depășesc rezistența de intindere a mixturii asfaltice. Micșorarea tensiunilor de întindere din mixtura asfaltică se poate realiza prin interpunerea discontinuă a unui sistem antifisură între aceasta și structura rutieră. Acest sistem poate fi fibra de sticlă sau geocompozitul din fibră de sticlă. In situația reală, pe drumurile publice, creșterea încărcărilor pe osie conduce la o creștere a valorii efortului de întindere la baza stratului de mixtură asfaltică.*

Abstract. *The paper aims to demonstrate the action of reinforcement of the bituminous mixture with fiberglass on cracking resistance. Thru laboratory tests it will be verified the effect of fiberglass reinforcement of bituminous mixtures on the deformations under cyclic loading, compared to one unarmed. The initiation of cracks and their propagation are caused by the tensile stresses, which exceed the tensile strength of the bituminous mix. The reduction of the tensile stresses in the bituminous mixture can be achieved by interposing between it and the discontinuous road structure of an anti-crack system. This system can be fiberglass or fiberglass geocomposite. In the real situation, on the public roads the increase of axle loads leads to an increase in the value of the stretching effort at the base of the bituminous mixing layer.*

Keywords: Bituminous mixture, Fiberglass

1. Introduction

The use of fiberglass in bituminous mixtures increases the elasticity and mechanical resistance of these materials, confers resistance to temperature variations, to aging of materials and to aggressive chemicals.

By introducing a fiberglass geocomposite, production, propagation and transmission of cracks in the bituminous mixture layer are delayed.

2. Establishing the bituminous mixture recipe

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The designed surface course is a BA 16 roll 70/100 bituminous mixture consisting of natural sand, crushed sand, crushed quarry aggregates, filler and road bitumen type 70/100, according to SR EN 13108-1: 2006 [1].

The grading of the aggregates (Table 1 and Fig. 1) is within the limits established by the standard, and the optimum bitumen content (Table 2, 3) was determined by making Marshall cylindrical specimens with different percentages of bitumen and carrying out the necessary laboratory tests [2, 3, 4, 5, 6].

Table 1. Grading of the aggregates.

Aggregate	Grading class	Mixture ratio	**5,0**	**5,5**	**5,7**	**5,9**	**6,1**
NN	0/4	9,00%	8,550	8,505	8,487	8,469	8,451
NC	0/4	25,00%	23,750	23,625	23,575	23,525	23,475
Broken stone	4/8	26,00%	24,700	24,570	24,518	24,466	24,414
Broken stone	8/16	31,00%	29,450	29,295	29,233	29,171	29,109
Filler	Limestone	9,00%	8,550	8,505	8,487	8,469	8,451
Total - aggregate			95,000	94,500	94,300	94,100	93,900
Total - bitumen			5,000	5,500	5,700	5,900	6,100
Total - mixture:		100	100	100	100	100	100

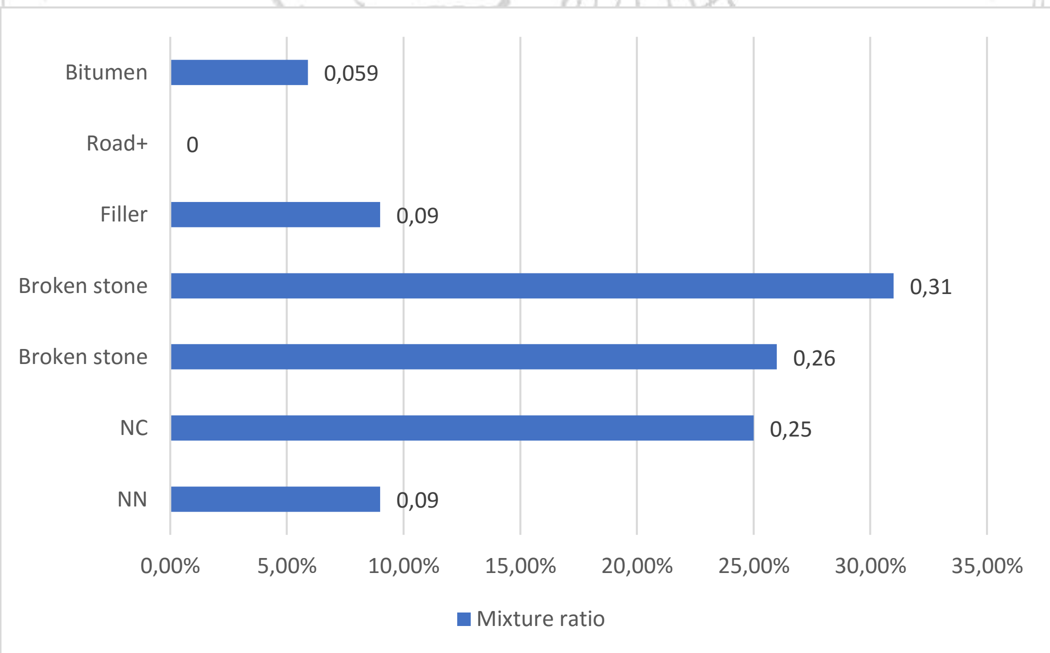

Fig. 1. Mixture ratio for all aggregates.

Table 2. Weight of materials for 1000 Kg of mixture.

Aggregate	Grading class	Material weight (Kg) / 1000 Kg mixture				
NN	0/4	85,50	85,05	84,87	84,69	84,51
NC	0/4	237,50	236,25	235,75	235,25	234,75
Broken stone	4/8	247,00	245,70	245,18	244,66	244,14
Broken stone	8/16	294,50	292,95	292,33	291,71	291,09
Filler	Calcar	85,50	85,05	84,87	84,69	84,51
Bitumen	70/100	50,00	55,00	57,00	59,00	61,00
Mixture charge, kg :		**1000,00**	**1000,00**	**1000,00**	**1000,00**	**1000,00**

Table 3. Determining the optimal percentage of bitumen.

Nr. crt.	Characteristic	Mixture (percentage of bitumen (%))					Values according SR EN 13108-1
		5,0	5,5	5,7	5,9	6,1	TL min 5,6
1	Stability (S) at 60 ^{0}C, kN	5,9	8,3	10,2	7,9	5,2	**5,0…15,0**
2	Flow index (creep), mm	2,7	3,0	3,3	3,6	4,2	**F1,5…F4,0**
3	Apparent density, kg/mc, min.	2,361	2,378	2,388	2,374	2,357	
4	Water absorption, %, vol.	3,6	3,1	2,8	2,4	2,0	
5	Raport S/I [KN/mm]	2,2	2,8	3,1	2,2	1,2	**Qmin 1,5**
6	Voids content Vv [%]	5,6	4,2	3,5	3,8	4,2	**2…10**
7	Percentage voids filled with bitumen VFB [%]	61,5	69,4	73,2	72,7	72,5	**70…80**
8	Percentage minimum voids in aggregate VMA [%]	17,47	17,32	17,15	17,81	18,39	**min 12**

In order to determine the vertical deformations and the number of loading cycles until cracking, the behavior of tests made of simple bituminous mixture (M1), bituminous mixture with fiberglass 0.4% (M2) and bituminous mixture reinforced with fiberglass geocomposite (M3) was studied, at cyclic bending with a pressure of 100 kPa.

The introduction of glass fibers in the bituminous mixture increases the elasticity and mechanical resistance of these materials, confers resistance to temperature variations, to the aging of materials and to aggressive chemicals.

By introducing a fiberglass geocomposite, production, propagation and transmission of cracks and cracks in the bituminous mixing layer are delayed.

For each proposed alternative three test specimens were made and tested.

The bituminous mixture specimens were made as follows (Fig. 1, 2, 3):

- weigh an amount of 1840 g / bituminous mixture specimen to obtain the following dimensions of the bituminous mixture specimen: length 20 cm, width 10 cm, thickness 4 cm

- a mold for concrete with dimensions 100x100x550 mm is used, at which they were placed at distal ends to obtain the corresponding dimensions

- the mixture is heated to 180 ° C

- insert into the mold, put on a device specially adapted for compaction and compact with a press, under a load of 150 kN for 3 minutes

- at M2 the amount of fiberglass was homogenized with the bituminous mixture after preparation

- at M3 the fiberglass geocomposite is placed after half of the mixture has been placed in the mold, after which it is covered again with the mixture

Fig. 1. Making the specimens.

Fig. 2. Preparing the bituminous mixture with geocomposite.

Fig. 3. Specimens up for testing

3. Testing the specimens

The specimens are tested to cyclic bending after 24 hours with ELE MATTA equipment at 22 ^{0}C room temperature, with a deviation of ± 1 ^{0}C.

Place the specimen on a support adapted to the test so that it is well centered and adjust the position of the transducers (TDLV) for measuring the deformations, so that the translators have a maximum stroke. The distance between the supports is 10 cm.

Lower the actuator support frame so that the actuator piston has an optimal stroke. Check the horizontality of the frame and tighten its mounting screws.

The force is applied by means of a distribution plate positioned in the middle of the plate (Fig. 4).

The compressed air source is connected to the equipment.

Start the computer, open the "UMAT" program and program the equipment for cyclic compression testing.

General test data and working parameters are entered in the UMAT program by selecting the edit command.

The translators are set to zero and the test begins by recording the deformations and following the test process on the computer monitor (Fig. 5).

The test stops with cracking or breaking the specimen (Fig. 6).

Fig. 4. Normal mixture specimen – cracked and broken.

Fig. 5. Mixture reinforced with geocomposite – cracked without broke

Fig. 6. Test recording

The number of cycles at the crack is recorded on the graph of deformations for each specimen (Fig. 7, 8). Three values of vertical deformations were recorded for each mixture (M1, M2, M3) and the statistical values were processed (Table 4).

4. Results

Table 4. Deformations for each specimen

No.	Specimen	Deformations (µm)
1	Bituminous mixture BA16 rul 70/100 reference (M1)	59520
2		64210
3		57305
Average:		**60345**
Standard deviation, µm		3525,7
Coefficient of variation, %		5,8
1	Bituminous mixture BA16 rul 70/100 with fiberglass (M2)	53025
2		48435
3		49154
Average:		**50205**
Standard deviation, µm		2468,8
Coefficient of variation, %		4,9
1	Bituminous mixture BA16 rul 70/100 with geocompozit and fiberglass (M3)	25192
2		23302
3		28878
Average:		**25791**
Standard deviation, µm		2835,8
Coefficient of variation, %		11,0

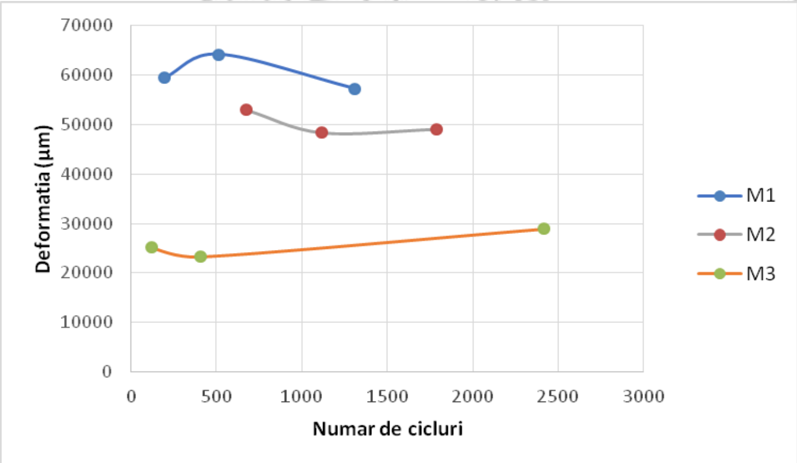

Fig. 7. Graphical representation of deformations according to the number of loading cycles.

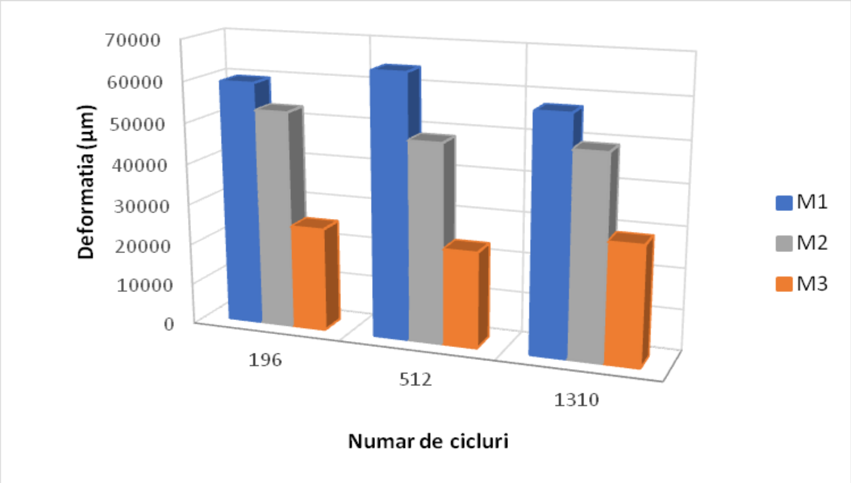

Fig. 8. Graphical representation of deformations at the same loading cycle.

Interpretation of results:

Following the analysis of the results of the cyclic bending tests of the bituminous mixtures, the following were found:

- the reference bituminous mixture (M1) and the fiberglass bituminous mixture (M2) cracked and broke in two;

- Bituminous mixture reinforced with geocomposite material (M3) after cracking continued to take over;

- the values of the vertical deformation at the crack followed by breaking for the fiberglass mixture are 16.8% lower than the values of the reference mix;

- the values of the vertical deformation at the crack for the fiberglass geocomposite mixture are 57.3% lower than the values of the reference mix.

5. Conclusions

The initiation of cracks and their propagation are caused by the tensile stresses, which exceed the tensile strength of the bituminous mixture.

In the real situation, on public roads, the increase of axle loads leads to an increase in the value of the stretching effort at the base of the bituminous mixing layer.

The use in the bituminous of glass fibers or glass fiber geocomposite materials increases the time of cracks occurrence, decreases the value of vertical deformations and in the case of geocomposites, the wear layer continues to take over the loads thus extending the duration until the next road rehabilitation execution. .

R E F E R E N C E S

[1] SR EN 13108-1: 2006 Mixturi asfaltice.Specificatii pentru materiale. Betoane asfaltice / Bituminous mixtures - Material specifications - Part 1: Asphalt Concrete.

[2] SR EN 12697-1:2012 Mixturi asfaltice. Metode de încercare pentru mixturi asfaltice preparate la cald. Partea 1: Conţinut de liant solubil / Bituminous mixtures. Test methods for hot mix asphalt. Part 1: Soluble binder content

[3] SR EN 12697-6: 2012 Mixturi asfaltice. Metode de încercare pentru mixturi asfaltice preparate la cald. Partea 6: Determinarea densităţii aparente a epruvetelor bituminoase / Bituminous mixtures. Test methods for hot mix asphalt. Part 6: Determination of bulk density of bituminous specimens

[4] SR EN 12697-8: 2019 Mixturi asfaltice. Metode de încercare. Partea 8: Determinarea caracteristicilor volumetrice ale epruvetelor bituminoase / Bituminous mixtures - Test methods - Part 8: Determination of void characteristics of bituminous specimens

[5] SR EN 12697-25: 2012 Mixturi asfaltice. Metode de încercare. Partea 25: Încercare la compresiune ciclică / Bituminous mixtures - Test methods - Part 25: Cyclic compression test

[6] SR EN 12697-34: 2012 Mixturi asfaltice. Metode de încercare pentru mixturi asfaltice preparate la cald. Partea 34: Încercare Marshall / Bituminous mixtures - Test methods - Part 34: Marshall test