

Research on the impact of SMA11 mixtures gradation on permanent deformation rate.

Martins Zaumanis and Viktors Haritonovs (Faculty Mentor)
 Institute of transportation
 Riga Technical University
 Riga, Latvia
 Email: jeckabs@gmail.com

Abstract - The aim of the research is to determine the impact of stone mastic asphalt gradations on permanent deformation rate. Four compositions of SMA-11 with different grading compositions were made in a full scale asphalt plant and two equally graded mixtures using different additives were mixed in a laboratory. Different raw material fractions of granite were used to vary the number of voids and the structure of the mineral carcass. Road bitumen 70/100 was used as binder. Asphalt slabs were made using roller compactor and tested with the help of a wheel tracking method. The results show a clear correlation between the number of air voids, grading composition and additives used in the mixture with performance observed in the wheel tracking test.

I. METHODS

By variation of grading composition and material fraction, four different asphalt mixtures SMA-11 [1] are produced in a full scale asphalt plant and two equally graded specimens are mixed in the laboratory. AMOMATIC VS 150S asphalt plant is used. For each type of mixture two slabs are made: one for determining particle size distribution [2], soluble binder content [3] and void characteristics [4] with the Marshall Method [5] and one for the wheel tracking test (WTT) [6]. Asphalt slabs used in the WTT have been manufactured by roller compactor according to EN 12697-33 [7]. Thickness of the

specimens corresponds to that of the field compacted layer, in this case 40mm. The wheel tracking test is performed in accordance with EN 12697-22 – the standard method for a small size device for testing in air, procedure B. Testing conditions are fixed in EN 13108-20 [8]. Testing is performed at +60°C – the wearing up temperature of the asphalt pavement surface during the hottest summer days [9], when the rut formation dynamics are the largest. 10000 cycles are performed. The equipment in the laboratory circumstances simulates the asphalt slab specimen load, which is close to the actual heavy transport load on asphalt pavement; in this case the applied load is 700N for a rubber wheel of diameter 200mm and width of 50mm.

The mineral materials used are from the same quarry and have similar properties. The materials used in each sample and composition of materials for production is shown in Table 1.

II. RESULTS AND DISCUSSION

The results obtained by testing the asphalt specimens using the Marshall Method together with the requirements of Road specifications 2005 [10] in Latvia, are shown in Table 2. This table also contains estimated values for wheel tracking slope (WTS_{AIR}) and proportional rut depth (PRD_{AIR}) and highest and lowest categories of EN 13108-5. Developments of rut deformations are in Figure 1.

Sample Nr.	Date of production	Consumptions of aggregates for plant primary dozation, %				Precise dozation on asphalt plant, kg					Fibre additive "Antrocell", % of mixture mass	Adhesion additive "Stardope", % of bitumen
		8-11 granite	5-8 granite	2-5 grante	0-5 granite	0-6mm bunker	6-10mm bunker	10-14mm bunker	Dolomite powder	Road bitumen 70/100		
Nr.1	09.06.2009	78	-	-	22	220	127	490	100	63	0.40%	0.24%
Nr.2	13.10.2008	63	14	6	17	309	484	43	100	64	0.40%	0.24%
Nr.3	12.06.2009	78	-	-	22	220	124	482	110	64	0.40%	0.24%
Nr.4	04.06.2009	84	-	-	16	244	296	296	100	64	0.40%	0.24%
Consumptions of asphalt mixtures, mass%												
Nr.5	15.11.2008	53	12	4.7	14	Mixed in laboratory			10.0	6.3	0.40%	0.24%
Nr.6	15.11.2008	53	12	4.7	14				10.0	6.3	0.40%	-

Table 1: Compositions of asphalt mixtures

Sieve	Particles passing sieve, mass%						Requirement in LV	
	Nr. 1	Nr. 2	Nr. 3	Nr. 4	Nr. 5	Nr. 6	max	min
0.063mm	9.6	8.9	9.7	9.7	10.8	10.8	12	8
0.125mm	11.2	11.6	11.4	10.8	12.8	12.8	15	9
0.25mm	13.5	15.8	14	12.9	14.6	14.6	20	10
0.5mm	16.9	20.3	17.6	15.9	16.4	16.4	24	12
1mm	20.3	23.7	21	19.4	17.9	17.9	27	15
2mm	28.3	30.9	27.9	28.5	21.6	21.6	30	19
4mm	32.6	40.9	31.4	33.9	30.1	30.1	35	24
5.6mm	34.6	48.4	33.2	36.4	36.7	36.7	40	27
8mm	48.9	65.2	47.2	48.6	49.7	49.7	60	35
11.2mm	91.8	91.4	89.3	93	94.9	94.9	99	85
16mm	100	99.7	100	100	100	100	100	98
Bitumen (B), %	6.2	6.0	6.1	5.9	6.0	6.0	B_{maxNR}	$B_{min6.0}$
Air voids (V), %	5.8	2.1	2.9	5.6	5.6	5.5	$V_{max3.5}$	$V_{min2.0}$
Voids filled with bitumen (VFB), %	71.6	87.5	83.8	71.5	72.6	72.7	VFB_{max90}	VFB_{minNR}
Wheel Tracking test						Requirement of EN 13108-5		
WTS_{AIR} , mm/10 ³ cycles	0.13	0.07	0.06	0.12	0.06	0.10	$WTS_{AIR1.0}$	$WTS_{AIR0.3}$
PRD_{AIR} , %	7.55	6.53	6.05	7.75	6.23	7.93	$PRD_{AIR5.0}$	$PRD_{AIR1.0}$

Table 2: Specimen testing results

All of the mixtures satisfy the highest category of $WTS_{AIR0.3}$ more than twice and there is a clear correlation between the number of air voids in the mixture and the wheel tracking slope - the fewer the number of voids present, the smaller is the wheel tracking slope. The situation is the same for the PRD_{AIR} test if the results are compared - minimization of the number of air voids improves the results. But in the case of evaluating PRD_{AIR} , it is clear that rut depth exceeds the minimal requirement of PRD_{AIR5} for all specimens. As the wheel tracking slope is calculated from the last 5000 cycles and the results are very satisfying, but PRD_{AIR} is estimated over the entire range of the experiment, including the first - the stabilisation part, then it is fair to say that unsatisfactory results, as we can see from the Figure 1, are mostly observed during the first 2000 cycles, when the rate of rut depth growth is the largest. The connection between aggregate gradation and performance in the wheel tracking test may be established if the specimen has a similar amount of air voids. For mixtures closer to the minimal requirements of number of particles passing the sieve, the results for both assessments improve noticeably. Also, it is clear that the usage of adhesion additive improves performance in the wheel tracking test - WTS_{AIR} is improved by 40% and PRD_{AIR} - by 21%.

III. CONCLUSIONS

1. Usage of adhesion additive greatly improves performance in the wheel tracking test.
2. All of the specimens satisfy the highest category of WTS_{AIR} , but exceed the lowest category of PRD_{AIR} . However reducing the number of air voids improves performance in both cases.

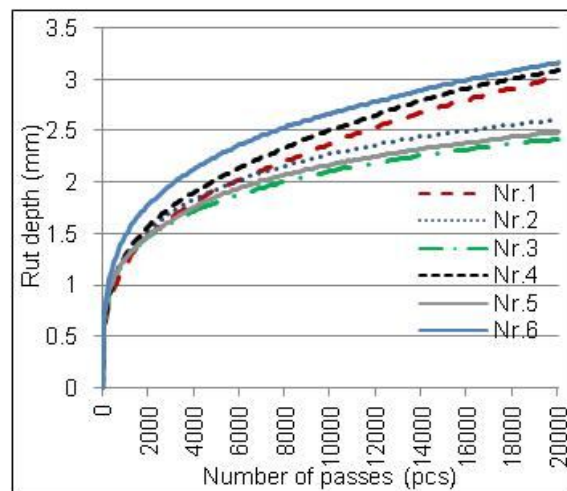


Figure 1: Development of rut depths

3. Designing mixtures closer to the minimal requirements of particles passing the sieves improves results for both assessments.

REFERENCES

- [1]. EN 13108-5 Bituminous mixtures – Material specifications – Part 5: Stone mastic asphalt
- [2]. EN 12697-2 Bituminous mixtures – Test methods for hot mix asphalt – Part 2: Determination of particle size distribution
- [3]. EN 12697-1 Bituminous mixtures – Test methods for hot mix asphalt – Part 1: Soluble binder content
- [4]. EN 12697-8 Bituminous mixtures – Test methods for hot mix asphalt – Part 8: Determination of void characteristics of bituminous specimens
- [5]. Tom V. Mathew, K V Krishna Rao. Marshall Mix Design. In Proceedings of National Programme on Technology Enhanced Learning, Chapter 26, India, May 2007
- [6]. EN12697-22 Bituminous mixtures- Test methods for hot mix asphalt- Part 22:Wheel tracking
- [7]. EN 12697-33 Bituminous mixtures – Test methods for hot mix asphalt – Part 33:Speciman prepared by roller compactor
- [8]. EN 13108-20 Bituminous mixtures – Material Specifications – Part 20: Type testing
- [9]. V.Haritonovs, J.Naudžuns, J.Smirnovs. Determining the reasons for formation of pavement rutting. In Proceedings of Civil Engineering 2005 International scientific conference LLU Jelgava, pages 52-58, Jelgava, Latvia, 2005.
- [10]. Road Specifications 2005. SIA „Balthous poligrāfija”, page 67, Riga, Latvia, August 2004.