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ASPHALT STRUCTURE FOR THE CIRCULAR ROADWAY

While driving through the roundabout, the thrust and frictional forces act on the asphalt pavement of the roundabout through the contact between the vehicle tires and the roundabout pavement. The circular roadways at roundabouts are exposed to special traffic loads due to cornering, namely friction and shear stresses, and in smaller roundabouts (mini roundabouts) also torsional stresses (turning of tires on the spot). Especially due to the high proportion of heavy traffic, damage to the asphalt pavement is often found, such as cracks, unevenness (indentations, ruts), etc.

Therefore, it is extremely important to counteract the development of asphalt road damage by selecting the right asphalt construction for the roundabout pavements. In order to avoid possible under dimensioning, it is recommended to generally choose the next higher load class - deviating from the RStOs (guidelines for standardization of pavements of traffic surfaces (GER)) in relation to the most heavily loaded section of the roundabout.

Keywords: roundabout, asphalt, bitumen, road construction

1. GERMAN RECOMMENDATIONS FOR THE ASPHALT STRUCTURE FOR THE CIRCULAR ROADWAY

According to [1] when dimensioning the roadway structure of the roundabouts, the calculated load class is increased by one load class in order to enable the absorption of the increased shear stresses (Fig.1) on the asphalt structure of the roundabout by appropriate road construction and building materials:



Figure 1. Shear stresses (Fig.1) on the asphalt structure of the roundabout [Hrapović K. 06.11.2015]

Bearing (base) course: AC 32 T S with 30/45

Binder course: AC 16 B S with 25/55-55

Asphalt surface course: AC 11 D S – Sp with 25/55-55

Declaration:

AC = Asphalt Concrete

11 = maximum particle size 11 mm

16 = maximum particle size 16 mm

32 = maximum particle size 32 mm

D = Asphalt surface course

B = Binder course

T = Bearing (base) course

S = special load

Sp = Asphalt concrete with crushed aggregate (chipping)

25/55-55 = Bitumen with penetration between $(25 - 55) \times 10^{-1}$ mm and softening point +55 °C (Ring and Ball method)

10/40-65 = Bitumen with penetration between $(10 - 40) \times 10^{-1}$ mm and softening point +65 °C

30/45 = Bitumen with penetration between $(30 - 45) \times 10^{-1}$ mm

SMA = Stone Mastic Asphalt

Sp = “Splitt” (germ.) = crushed aggregate (chipping)

Based on the damage analysis of asphalt circular roadways according to German guidelines and regulations, the following is recommended [1]:

- a) Create paving plan / finisher plan
- b) Avoid manual installation
- c) No longitudinal seam in the circular carriageway, if possible, installation over the entire width of the circular carriageway
- d) Building under traffic avoid as far as possible
- e) No cover or manholes in the circular roadway
- f) use hard binders e.g., PmB (polymer bitumen)
- g) No Stone Mastic Asphalt as surface course, also recommendation of the relevant FGSV committees

Instead of SMA asphalt for the asphalt surface of the circular roadway use the chippy asphalt: AC 11 D S-Sp.

Technical characteristics of these asphalt mix are:

- Continuous grading with high chipping content (crushed/broken particle) and large cant (fig.2, fig.3)
- Good embedding of the aggregates in the large mortar phase with high strength.

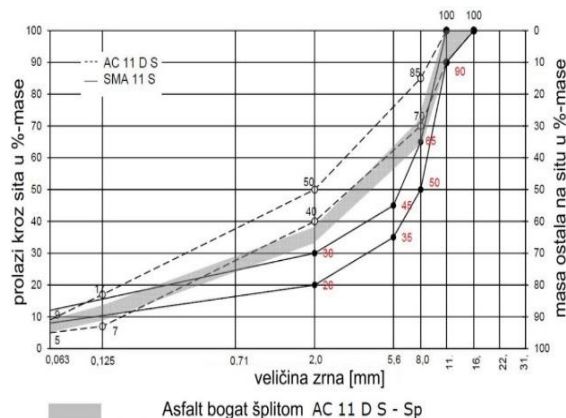


Figure 2. Grading envelope of the asphalt mix: AC 11 D S and SMA 11 [1]

gradjevinski materijali	jedinica mjere	uslovi
zrna agregata	-	gruba zrna agregata, fina drobljena zrna agregata, kretnjački filer (kamenno brašno)
udio drobljenih zrna	-	min. C ₉₅ ¹ udio potpuno drobljenih zrna min. 60 %-mase
najmanji udio finih zrna agregata E _{cs35}	%	100
otpornost protiv stinjenja pri udaru	-	SZ ₁₀ LA ₂₀
otpornost protiv habanja PSV	-	51
vezivo, vrsta i sorta veziva	-	25/55-55 A ili tvrdiji bitumen
mješavina zrna agregata		
udio grubih zrna agregata	M.-%	cilj: 65
asfaltna mješavina		
udio šupljina ispunjenih vazduhom MPK	Vol.-%	2,5 do 3,5
veličina deformacije asfaltnog cilindričnog uzorka pod dejstvom pritiska i toplote prema TP A-SIB, Dio 2SB sa $\sigma_0 = 0,35 \text{ N/mm}^2$	$10^{-4} \text{ } \mu\text{m/n}$	≤ 3
sloj		
debljina ugradjivanja	cm	3,5 do 4,0
sadržaj šupljina u cilindričnom uzorku asfaltna	Vol.-%	2,5 do 4,5

Figure 3. Technical characteristics of the asphalt mix AC 11 D S-Sp [1]

The characteristics of these asphalt mix are:

- Very high shear strength
- Good processing properties
- Temperature susceptibility reduces
- Very high internal friction

2. AUSTRIAN RECOMMENDATIONS FOR THE ASPHALT STRUCTURE FOR THE CIRCULAR ROADWAY

Based on the empirical recommendations of asphalt circular roadways in Austria, the following is recommended (Fig.4):

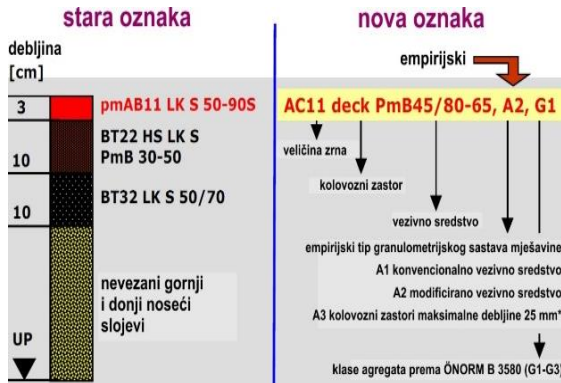


Figure 4. Asphalt pavement according to empirical recommendations in Austria [2]

Declaration:

3 cm AC11 deck PmB 45/80-65 A2, G1, LA15:

3 cm = Asphalt layer thickness

AC11 = Asphalt Concrete with a maximum particle size 11 mm

11 = maximum particle size 11 mm

deck = name for the top layer (here is surface course)

PmB 45/80-65 = polymer bitumen with penetration between (45 – 80) x 10⁻¹ mm and softening point +65 °C (Ring and Ball method)

A2 = asphalt type produced exclusively with modified binders (e.g. PmB) aggregate class of the asphalt mix according to Austrian standard (OENORM B 3580-1, 2018)

G1 = aggregate class of the asphalt mix according to Austrian standard (OENORM B 3580-1, 2018)

LA15 = Los Angeles value

10 cm AC32 binder PmB 25/55-55 H1, G4:

10 cm = Asphalt layer thickness

AC32 = Asphalt Concrete with a maximum particle size 32 mm

binder = binder

PmB 25/55-55 = polymer bitumen with penetration between (25 – 55) x 10⁻¹ mm and softening point +55 °C (Ring and Ball method)

H1 = highly stable base layer (binder)

G4 = aggregate class of the asphalt mix according to Austrian standard (OENORM B 3580-1, 2018) for binder and base courses as well as base and surface courses with low requirements or no requirements for skid resistance.

20 cm = unbound upper road base, with a maximum particle size 45 mm, C90/3, 20 cm thickness

C90/3 = Categories for the percentage of crushed particle surfaces (including the percentage of totally crushed (90%) and totally rounded (3%) particles) (EN 13043, 2015)

30 cm = unbound subbase with a maximum particle size 63 mm, 30 cm thickness

The empirical recommendations of asphalt mix AC11 deck PmB 45/80-65 A2, G1, LA15 according to Austrian guidelines are:

- Minimum binder content 3% percent by mass
- Siev sizes: 0,063-0,5-2-8-11-16
- Air voids content of aggregate: $V_{min} = 2\%$, $V_{max} = 4\%$ percent by volume
- Minimum temperature $min.T = +150^{\circ}C$ and maximum Temperature $max.T = +190^{\circ}C$ of this asphalt mix.
- The proportional rut depth $PRD_{air} = 7\%$ according to the European Standard EN 12697-22: bituminous mixtures - test methods - part 22: wheel tracking

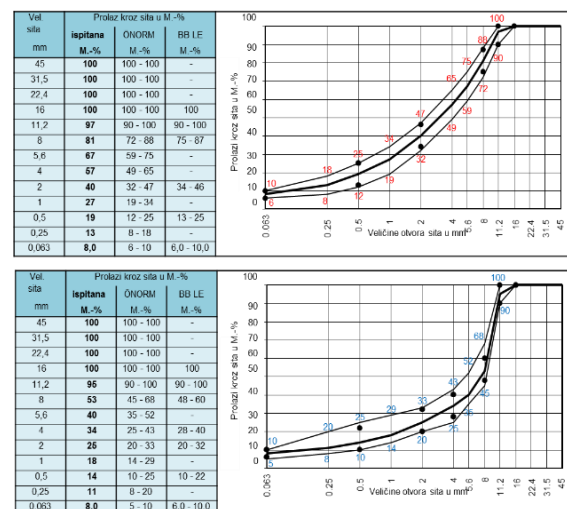


Figure 5. Direct comparison of grading curves of the asphalt mix AC11 deck PmB 45/80-65 A2, G1 (top) and asphalt mix SMA 11 PmB 45/80-65, S2, GS (below) [3]

On the figure 5 is shown direct comparison of grading curves of the asphalt mix AC11 deck PmB 45/80-65 A2,G1 and asphalt mix SMA 11 PmB 45/80-65,S2,GS according Austrian guidelines and regulations.

In Austria, similar to Germany (Fig.122), it is also very noticeable that AC11 asphalt concrete contains considerably finer fraction than SMA11 (Fig.6). the sieve with an opening width of 2 mm in the AC11 allows between 32-47 M-% (Fig.120) to pass through, while the SMA11 only has between 20 and 33 M-%. In the case of AC 11, as much as 72-88 mass percent passes through the 8 mm sieve, and in the case of SMA 11 it is only 45-68 M-%.

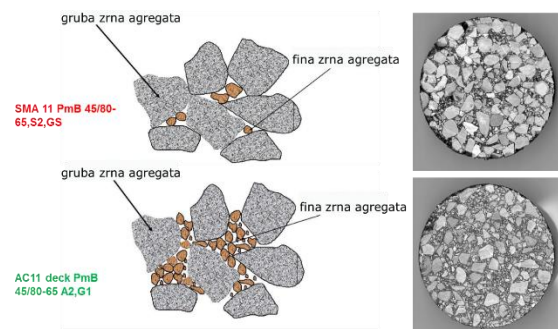


Figure 6. Direct comparison of the asphalt mix AC11 deck PmB 45/80-65 A2,G1 and asphalt mix SMA 11 PmB 45/80-65,S2,GS [4]

Tab.1 shows an initial test report for asphalt mix AC11 PmB 45/80-65, A2, G1 from an Austrian asphalt laboratory. The aggregate for this mix is made of basalt and a special fine crushed aggregate (EBK). E.g. 4/8 mm fine crushed aggregate contains 23.7 mass percent in this mix. The polymer modified bitumen PmB 45/80-65 is included in the mix in 5.4 mass per cent (Tab.1).

The designation 45/80-65 means that the penetration of the bitumen at +25°C is between 4.5 and 8 mm and the ring and ball softening point is +65°C.

Table 1. Initial test report for asphalt mix AC11 PmB 45/80-65, A2, G1 [5]

Dijelovi i sastav							
Zrna agregata	Nr.	oznaka	Postrojenje za proizvodnju asfalta	Broj sertifikata	napomena	Dodatak – potreban sastav u M.-%	
	1	EBK 0/2	Appel /fabrika Mühldorf	1159-CPR-0082/04	bazalt	35,0	33,1
	2	EBK 2/4	Appel /fabrika Mühldorf	1159-CPR-0082/04	bazalt	15,0	14,2
	3	EBK 4/8	Appel /fabrika Mühldorf	1159-CPR-0082/04	bazalt	25,0	23,7
	4	EBK 8/11	Appel /fabrika Mühldorf	1159-CPR-0082/04	bazalt	25,0	23,7
Reciklirani asfalt	Nr.	oznaka	porijeklo		Sadržaj VS M.-%		
	1	-	-		-	-	
Vezivo	Vezno sredstvo=VS (vezivo)		Elastična deformacija %	Broj sertifikata	TRPK °C	suma	
	Reciklirani asfalt		-	-	-	-	
	PmB 45/80-65		-	-	≥ 65	-	5,4
	Rezultirajuće vezivo		-	-	-	-	5,4
						100,0	
dodaci		Oznaka, vrsta i porijeklo				Udio u M.-%	

1) odnos do te mase, isključujući mešanje
2) odnos do te mase, uključujući agregate
3) odnos do te mase, uključujući bitumen

in the Tab.2 can be seen the Declaration of performance for the Austrian wearing course AC11 deck PmB 45/80- 65, A2, G1 with the limits values of all relevant parameters according to European and Austrian standards as well as the declared parameters on the basis of the manufacturer's test.

Table 2. Declaration of performance for the Austrian wearing course AC11 deck PmB 45/80- 65, A2, G1

AC11 deck PmB45/80-65, A2, G1					granične vrijednosti po ON B 3584-1		deklarirane vrijednosti prema atestu proizvođača	
parametri	standard	ozn.	jedinica	rezultat ispitivanja	min.	max.	min.	max.
Rastvoreni sadržaj veziva	EN 12697-1	S	M.-%	5,2	3,0	-	4,9	5,5
Gustina asfalne mješavine	EN 12697-5	r _{av}	Mg/m ³	2,582	-	-	-	-
Gustina zrna agregata	-	računski	Mg/m ³	2,780	-	-	-	-
Gustina probnog tijela	EN 12697-6	r _{total}	Mg/m ³	2,472	-	-	-	-
Sadržaj šupljina probnog tijela	EN 12697-8	V _v	V.-%	3,1	1,5	5,0	2,5	4,5
Sadržaj šupljina skeleta agregata	EN 12697-8	VMA	V.-%	16	-	-	-	-
Stepen ispunje šupljina	EN 12697-8	VFB	V.-%	80	-	-	-	-
Stabilnost po Marshall-u	EN 12697-34	S	kN	13,4	-	-	-	-
Tečenje po Marshall-u	EN 12697-34	F	mm	4,2	-	-	-	-
Odnos stabilnosti i tečenja po Marshall-u	EN 12697-34	S/F	kN/mm	3,2	-	-	-	-
Proporcionalna dubina koitraga	EN 12697-22	PRD _{air}	%	5,0	-	7,0	-	7,0
Očiscenje veziva	EN 12697-18	D	M.-%	0,0	-	-	-	-
Dubina prodiranja	EN 12697-21	l _{max}	mm	-	-	-	-	-
Maksimalni gubitak zrna	EN 12697-17	PL	M.-%	-	-	-	-	-
Ponašanje pri likovnom požaru	EN 13501-1	-	V.-%	12,6	-	16,9	-	-
Afinitet	EN 12697-11	-	%	98	80	-	80	-
Prolaz kroz karakt. grubo sito 8 mm	EN 12697-2	-	M.-%	81	72	88	75	87
Prolaz kroz sito 4 mm	-	-	M.-%	-	-	-	-	-
Prolaz kroz sito 2 mm	-	-	M.-%	40	12	47	34	46
Prolaz kroz karakt. fino sito 0.5 mm	-	-	M.-%	19	10	25	13	25
Prolaz kroz sito 0.063 mm	-	-	M.-%	8,0	6,0	10,0	6,0	10,0
Djelimično drobljena zrna agregata	EN 933-5	C ₁	M.-%	100	100	-	-	-
Potpuno drobljena zrna agregata	-	C ₂	M.-%	100	90	-	-	-
Potpuno okrugla zrna agregata	-	C ₃	M.-%	0	-	0	-	-

According to the European Standard EN 12697-22: bituminous mixtures - test methods - part 22: wheel tracking, the proportional rut depth PRD_{air} (germ. PRD_{Luft}) of the tested material (asphalt specimen) it amounts 5 %.

In Tab.2 it can also be seen that the limit value for the asphalt type AC11 deck PmB 45/80-65 A2, G1, LA15, PRD_{air} =7 %.

3. CONCLUSIONS

Based on the damage analysis of asphalt circular roadways, the following is recommended:

- Create paving plan / finisher plan
- Avoid manual installation
- No longitudinal seam in the circular carriageway, if possible installation over the entire width of the circular carriageway
- Building under traffic avoid as far as possible
- No cover or manholes in the circular roadway
- use hard binders e.g. PmB (polymer bitumen)
- No Stone Mastic Asphalt as surface course, also recommendation of the relevant FGVS committees
- Instead of SMA asphalt for the asphalt surface of the circular roadway use the

chippy asphalt in German: AC 11 D S-Sp

- i) Instead of SMA asphalt for the asphalt surface of the circular roadway use the chippy asphalt in Austria: AC11 deck PmB 45/80-65 A2, G1, LA15

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