International Journal of Multidisciplinary Research and Publications
ISSN (Online): 2581-6187

Required Properties of Mastic Asphalt for Use in Road Construction

Kerim Hrapović
EUR ING Civil Eng. PhD. Mst. in AUSTRIA
Email address: kerimhrapovic046@gmail.com

Abstract**—** *An important field of application for stable and ageing-resistant mastic asphalt is the use in road construction, highway construction or on bridges. Unlike the other types of asphalt, mastic asphalt has almost no voids and can be laid in a self-compacting manner. The aggregates "float" in the mastic (bitumen and filler) and have only a few points of contact with each other. For this reason, the aggregate has a minor influence on the stability of the mastic asphalt compared to rolled asphalt. To ensure sufficient deformation stability, it is necessary to use very hard bitumen. The hard bitumen and the high mastic content are a prerequisite for paving temperatures of up to +250 °C, so that a lower deformation stability can be achieved.*

Keywords**—** *Mastic asphalt; road construction; bitumen; filler.*

I. INTRODUCTION

Typical particle size distributions for the individual mix types with the nominal maximum particle size of 11 mm is shown in fig.1. There are three basic principles and model mechanisms of structural load-bearing behaviour of asphalt: 1. Mastic concept with viscous behaviour and adhesion as the principle (MA); 2. Packing concept with plastic behaviour and friction as the principle (AC); and 3. Supporting framework concept with elastic behaviour and support as the principle (SMA and PA) (Fig.1).

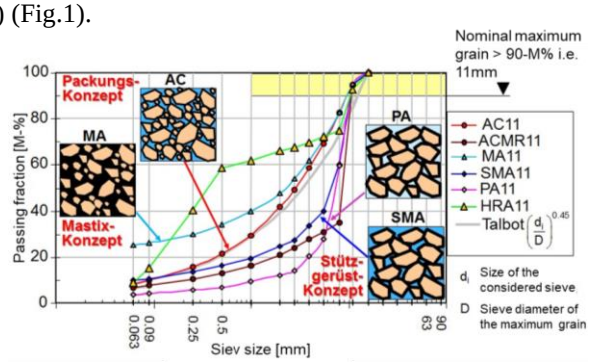

Figure 1. Comparison of typical grading curves of different asphalt pavements with maximum grain size 11 mm [1]

II. AUSTRIAN STANDARDS AND GUIDELINES RELATING TO MASTIC ASPHALT

In Austria, the European standard for mastic asphalt are EN 13108-6, 2016 [2] and Austrian national standard OENORM B 3585-1, 2018 [3] (Tab.1). According to this standard, mastic asphalt is a void-free asphalt mix with bitumen as a binder, in which the volume of filler and binder exceeds the volume of the remaining voids in the mix.

According to OENORM B 3585-1 [3] define, on the basis of geographical, topographical and climatic conditions, the requirements for mastic asphalt (mastic asphalt MA) for use in the construction of roads, airfields and other traffic areas. The requirements for delivery particle size D < 0.125 mm (filler) are given in table I. For the production of mastic asphalt, only the aggregate classes G1, G2, G3 and GS are permitted. The use of reclaimed asphalt is not permitted.

TABLE I. Requirements for delivery particle size D < 0.125 mm (filler) to OENORM B 3585-1, 2018 [1, 6].

Reference to ÖNORM EN 13043:2004		For the CE-marking, the Categories[a] or values	
Section	Feature	G1, G2, G3, GS	G4, G5, G6, G7, G8, G9
5.2.1	Particle size distribution according to EN 933-10	ÖNORM EN 13043:2004, Table 24	
5.2.2	harmful fine particles according to EN 933-9	MB_FNR	
5.3.2	Bulk density according to EN 1097-7	defined value	
5.3.3.1	Dry void content according to ÖNORM EN 1097-4	$V_{28/38}$	$V_{28/45}$
5.3.3.2	Delta ring and ball according to ÖNORM EN 13179-1	$\Delta_{R\&B}NR$	
5.4.1	Water solubility according to ÖNORM EN 1744-4	WS_{NR}	
5.4.2	Water sensitivity according to ÖNORM EN 1744-1	not required	
5.4.3	Carbonate content of carbonate fillers according to ÖNORM EN 196-2	CC_{80}	
5.4.4	Calcium hydroxide content of mixed fillers according to ÖNORM EN 459-2	Ka_{25}	
5.5.2	Bitumen number according to ÖNORM EN 13179-2	$BN_{28/39}$	

[a] The category "NR" or "not required" leads to the indication "NPD" in the manufacturer's declaration.

A distinction is made between two types (M1, M2) with a maximum particle size of 4 mm, 8 mm or 11 mm. The permissible grading curves MA 4, MA 8 and MA 11 are shown in table II.

TABLE II. Grading curve limit for mastic asphalt [1, 6].

Siev size	MA 4 (all types)	MA 8 (all types)	MA 11 (all types)
mm	passing fraction Mass fraction in %	passing fraction Mass fraction in %	passing fraction Mass fraction in %
16	–	–	100
11,2	–	100	90 bis 100
8[a]	–	90 bis 100	70 bis 90
5,6	100	–	–
4[b]	90 bis 100	65 bis 90	–
2	65 bis 80	53 bis 68	45 bis 60
0,5[c]	35 bis 50	30 bis 45	30 bis 45
0,063	24,0 bis 32,0	22,0 bis 30,0	20,0 bis 28,0

[a] characteristic large sieve for MA 11
[b] characteristic large sieve for MA 8
[c] characteristic fine sieve

In Austrian standard OENORM B 3585-1 [3] the minimum values to be fulfilled are fixed, such as minimum binder content B_{min}, minimum value of the penetration depth after 30 min I_{min}, maximum value of the penetration depth

Kerim Hrapović, "Required Properties of Mastic Asphalt for Use in Road Construction," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 5, Issue 4, pp. 35-38, 2022.

after 30 min Imax, maximum increase after a further 30 min I_{nc} and maximum dynamic penetration depth I_{dyn}. The parameters to be fulfilled for mastic asphalt (types M1 and M2) are shown in table III.

TABLE III. Indentation (resistance to permanent deformation) for mastic asphalt [1].

Parameters	M1	M2
Minimum value of penetration depth, in mm, after 30 min	$I_{min1,0}$	
Maximum value of penetration depth, in mm, after 30 min	$I_{max3,5}$	I_{max5_0}
Maximum increase, in mm, after another 30 min	$I_{nc0,5}$	$I_{nc0,8}$
Maximum dynamic penetration depth in mm	I_{dynNR}	

According to RVS 08.97.05 [4] for high loads, normally corresponding to load classes S (new designation LK25), I (new designation LK10) and II (new designation LK4), according to RVS 03.08.63 [5], we recommend the AC deck grade with particle size distribution A2 and A3 and SMA with particle size distribution S1, each with aggregate G1.

III. Definition of Mastic Asphalt

Mastic asphalt (Germ. *Gussasphalt*) is a building material or mixture of chippings, sand, stone flour (filler) (Fig.2) and bitumen (fig.3) which is pourable and spreadable during paving. Additives such as polyethylene (PE), waxes, natural asphalts (fig.4), etc. are added to the mastic asphalt to improve its performance. Mastic asphalt is laid by hand or by machine with a special paver for mastic asphalt without compaction and with rolling in chippings by means of special rollers.

IV. Composition of Mastic Asphalt

Mastic asphalt is a building material or mixture of chippings, sand, stone flour (filler) (Fig.2) and bitumen (Fig.3). The stone flour is contained in the mastic asphalt with an aggregate particle size of 0 to 0.063 mm between 25 - 30 wt.%. dolomite, lime, quartz or basalt stone flour is normally used as filler.

The sand is added to the mastic asphalt with an aggregate particle size of 0 - 2 mm between 30 - 50 wt. %. Usually lime and dolomite sands are used for this purpose. If there are special requirements for internal friction, as in the case of roadways, then the highest stone class GS must be assumed.

Figure 2. Composition of the mastic asphalt: lime flour (filler), lime sand 0/2 mm and lime chipping 2/4 mm [1, 6]

The chippings as an integral part of mastic asphalt have a particle size > 2 mm, so that particle sizes 4, 8 and 11 mm are used for the production of mastic asphalt. Hard chippings with a content of 30 to 45 wt.% must be used for the trafficable surfaces.

Bitumen (fig.3) together with stone flour (filler), is the most important component of mastic asphalt, because the load transfer from traffic takes place via the mastic (mixture of bitumen and stone flour) and thus has a major influence on the stability of the asphalt. The following types of bitumen are used for the production of mastic asphalt: bitumen 90/10, 20/30, 30/45, 35/50, 50/70 and also road bitumen 70/100. Polymer modified bitumen are used, as well as PmB 25/55-55, 25/55-65, 45/80-50 and 45/80-65. The expected traffic load and climatic conditions influence the choice of bitumen.

Figure 3. Bitumen as an important component of mastic asphalt [1]

Additives such as plastics, waxes, natural asphalt (fig.4) are added to the mastic asphalt to further improve its properties.

The synthetic material (e.g. polyethylene) improves the stiffening of the mastic asphalt so that the mastic asphalt does not flow away, e.g. on a slope. Mastic asphalt is produced at a much higher temperature (from +220 to +250 °C) than "normal" hot asphalt. Waxes as an additive for producing mastic asphalt allow for lower mix temperatures at the same viscosity, which has a positive effect on energy savings and CO_2 emissions.

By adding suitable waxes, the paving temperature can be reduced by +30 °C at the same viscosity.

Natural asphalts, such as Trinidad Epuré from the island of Trinidad (Fig.4), Gilsonite from Nevada or Selenizza from Albania, as additives to the stone flour of the mastic asphalt, cause a smoother behaviour when the mastic asphalt mass is spread, which has a positive effect on the reduction of crack formation.

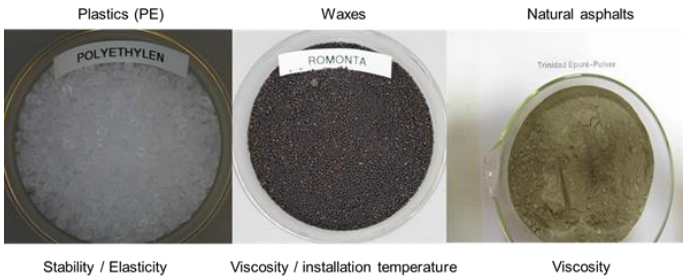

Figure 4. Additives for the production of mastic asphalt [1, 6]

V. Mechanical Properties of Mastic Asphalt

The main mechanical properties of mastic asphalt are shown in table IV.

TABLE IV. Mechanical properties of mastic asphalt [1].

Bulk density	2500 kg/m³
Incorporation thickness mm	25 to 35
Installation temperature	230 to 250 °C
Thermal conductivity	0.80 W/mK
Diffusion resistance	practically steam-tight
Water sensitivity	insensitive (even salt water)
Sound behavior	high internal damping
Dust formation	practically none
Fire behavior	DIN 4102-B1 flame resistant

Kerim Hrapović, "Required Properties of Mastic Asphalt for Use in Road Construction," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 5, Issue 4, pp. 35-38, 2022.

VI. Comparison between mastic asphalt and rolled asphalt

Fig.5 shows a comparison between mastic asphalt and rolled asphalt test specimens.

The difference between mastic asphalt and rolled asphalt is as follows:

- Composition of the aggregates
- Bitumen content and type of bitumen
- The rolled asphalt is laid by hand or with a paver and compacted by rollers and the mastic asphalt is applied in liquid form and does not need to be compacted.
- The production temperature of rolled asphalt is 160 ± 20 °C, which is considerably lower than that of mastic asphalt from +220 °C to +250 °C.

Figure 5. Mastic asphalt (left), rolled asphalt (right) [1]

VII. Installation of mastic asphalt

Mastic asphalt can be laid by hand on small sites (Fig.6a) or mechanically with a mastic asphalt paver (Fig.6b) on large sites such as roads or highways. The mastic asphalt is loaded directly from the cooker into wooden buckets or wheelbarrows and thus reaches the place of installation (Fig.6a). There the bucket or wheelbarrow is emptied, spread with wooden spreaders and painted in the correct position and thickness.

Figure 6. a) Manual laying of mastic asphalt [1]; b) Paving mastic asphalt by machine [1]

VIII. Asphalting of roundabouts

The roundabouts are also asphalted with the mastic asphalt. The roundabout in Hartberg in Styria on the B50 (km 46,250) was rehabilitated with mastic asphalt (Fig.7a). Nine years after its opening, the mastic asphalt at this roundabout looks very good (Fig.7b).

Figure 7a. Asphalting of the roundabout in Hartberg in Styria on the B50 in 2011 (Styria) [1, 6]

Figure 7b. The view from the roundabout roadway in Hartberg nine years after the rehabilitation on 16.11.2020 [1, 6]

IX. Asphalting roads and highways with mastic asphalt

In order to ensure the skid resistance of the road surface required for roads and highways, a bitumen-coated (impregnated) hard chippings with a particle size of 2/4 mm is spread (Fig.8a) and rolled in with special rollers (Fig.8b).

Figure 8a. Machine spreading of the hard chippings [1]

Figure 8b. Rolling in the hard chippings of mastic asphalt using rubber roller and smooth wheel roller [1]

What the finished surface of a 2 cm thick layer of mastic asphalt on a German highway looks like is shown in Fig.9a. On the left side of Fig.9b you can see the unrolled highway surface and on the right side of Fig.9b the rolled surface.

Figure 9. a) Paving MA on a German highway, 2cm thick when installed [1]; b) Left: unrolled highway surface, right: rolled highway surface [1]

Road surfaces with light-coloured surfaces make a special contribution to road safety. In addition, light-coloured asphalt

Kerim Hrapović, "Required Properties of Mastic Asphalt for Use in Road Construction," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 5, Issue 4, pp. 35-38, 2022.

pavements have a high resistance to deformation due to low heating. This in turn increases their service life and safety.

The areas renewed in Rhineland-Palatinate - on the A 48 in the Koblenz-Nord area and around the Bendorf Rhine Bridge as well as on the A 61 between Mendig and Wehr - are heavily frequented by truck traffic. Mastic asphalt was installed there because this road surface can absorb very high dynamic loads - and thus practically any traffic load - without damage. The projects were particularly innovative with regard to the grain size of the mastic asphalt and the use of a light-coloured scattering material [7].

In both projects, which are dimensioned according to load class Bk 100, a mastic asphalt MA 5 S was used instead of the usual MA 8 S. The smaller size grain results in a different ratio of binder to aggregate. The smaller maximum grain size results in a different ratio of binder to aggregate. This in turn allows the paving to be carried out in a lower layer thickness. A light-coloured scattering chippings can be applied over the entire surface, which ultimately promises advantages in terms of safety [7].

The low thickness of the mastic asphalt surface course of 2.5 cm or 3 cm requires, in return, an increased requirement for the evenness of the asphalt binder course analogous to a surface course. Accordingly, the tender had limited the unevenness in the binder course to a maximum of 4 mm on a 4 m long measuring section. On top of this, Schnorpfeil built the only 2.5 cm thin surface course of mastic asphalt MA 5 S. Directly during installation, the mastic asphalt was covered 100% with the light-coloured Henau quartzite of grain size 2/4 (Fig.10a). The material was applied to the hot surface in a spreading quantity of 11 kg/m² to 13 kg/m² with the integrated spreading device of the mastic asphalt screed [7].

Figure 10 a) Henau Quarzit 2/4 is not only exceptionally bright, but also impresses with its high PSV value and rough surface. [7]

Figure 10 b) One year after installation, the brightening is clearly visible, as here on the A 61 at the Wehr exit. [7]

Due to the use of the light-coloured Henau quartzite on the surface, no lightening components were necessary in the mastic asphalt itself. To ensure that the light-coloured scattering grit adhered securely to the entire surface, Schnorpfeil used a mastic asphalt with excess mortar. This forms a binder film on the surface of the mastic asphalt into which the scraper chippings can sink. In addition, the mastic asphalt is almost void-free due to the excess mortar. This circumstance is said to favour longevity, as the binder cannot age in the absence of air [7]. Fig.10b shows the A61 highway one year after asphalting.

X. Conclusion

Mastic asphalt has been used as a building material in road construction for over 150 years. During this time, it is not only the installation technique has changed, but also the demands on the material and its properties in the installed state. Due to the increasing traffic load on our federal roads and motorways, the requirements for stability for stability, durability and noise development. The installation of light-coloured mastic asphalt increases the resistance to deformation at summer temperatures, which is becoming increasingly relevant and important at our geographical latitudes due to global warming. On 11.08.2021, the highest air temperature ever measured in Europe was +48.8 °C in Sicily.

References

[1] Hrapović K.: Kolovozne konstrukcije u zemljama njemačkog govornog područja – projektovanje gradjenje i održavanje, published on 29.11.2021 and 01.12.2021 by Bookmundo / Rotterdam, Holland: ISBN: 9789403644714 (printed in color), ISBN: 9789403644516 (printed in black and white), https://publish.bookmundo.de/site/?r=userwebsite/index&id=kerimhrapovic/ ; Rotterdam, Holland, 2021

[2] ASI – Austrian Standards Institute: OENORM EN 13108-6 Asphaltmischgut - Mischgutanforderungen - Teil 6: Gussasphalt / Bituminous mixtures - Material specifications - Part 6: Mastic Asphalt, Vienna, 2016

[3] ASI – Austrian Standards Institute: OENORM B 3585-1 Asphaltmischgut - Mischgutanforderungen - Gussasphalt - Teil 1: Empirische Anforderungen - Regeln zur Umsetzung der OENORM EN 13108-6 / Bituminous mixtures - Material specifications - Mastic asphalt - Part 1: Empirical approach - Rules for the implementation of OENORM EN 13108-6, Vienna, 2018

[4] FSV – Forschungsgesellschaft Straße - Schiene – Verkehr / The Austrian Research Association for Roads, Railways and Transport: Guidelines for planning, construction and maintenance of roads RVS 08.97.05 Anforderungen an Asphaltmischgut / Requirements for asphalt mix, Vienna, 2010

[5] FSV – Forschungsgesellschaft Straße - Schiene – Verkehr / The Austrian Research Association for Roads, Railways and Transport: Guidelines for planning, construction and maintenance of roads RVS 03.08.63 Oberbaubemessung / Asphalt Pavement Design, Vienna, 2016

[6] Hrapović K.: Asphalt for roundabouts, 156 pages, Script in German for seminar "Asphalt for roundabouts", BWZ BAUAkademie Upper Austria, https://ooe.bauakademie.at/Kursdetail.aspx?ZG1=Q&ZG2=Qd&BBNR=414921; Steyregg, november 2021

[7] Heinz Schnorpfeil Bau GmbH: Laermminedernder Gussasphalt mit heller Absplittung aus Henauer Quarzit, STRASSE UND AUTOBAHN, 10 (2017) 4, pp. 830-831, FGSV, Cologne, 2017

[8] FGSV - Die Forschungsgesellschaft für Straßen- und Verkehrswesen e.V. / German Road and Transportation Research Association: Richtlinie für die Standardisierung des Oberbaus von Verkehrsflächen / Guidelines for standardization of pavements of traffic surfaces - RStO 12, Cologne, 2012