

asphalt

Warm mix asphalts



**Tips and tricks developed by
professionals for professionals**

Reference values for asphalt
temperatures when producing
warm mix asphalts

Reference temperature
for warm mix
at production

130 to 150 °C

30/45
25/55-55 A

140 to 160 °C

10/40-65 A

150 to 170 °C

30/45
20/30
25/55-55 A

200 to 230 °C

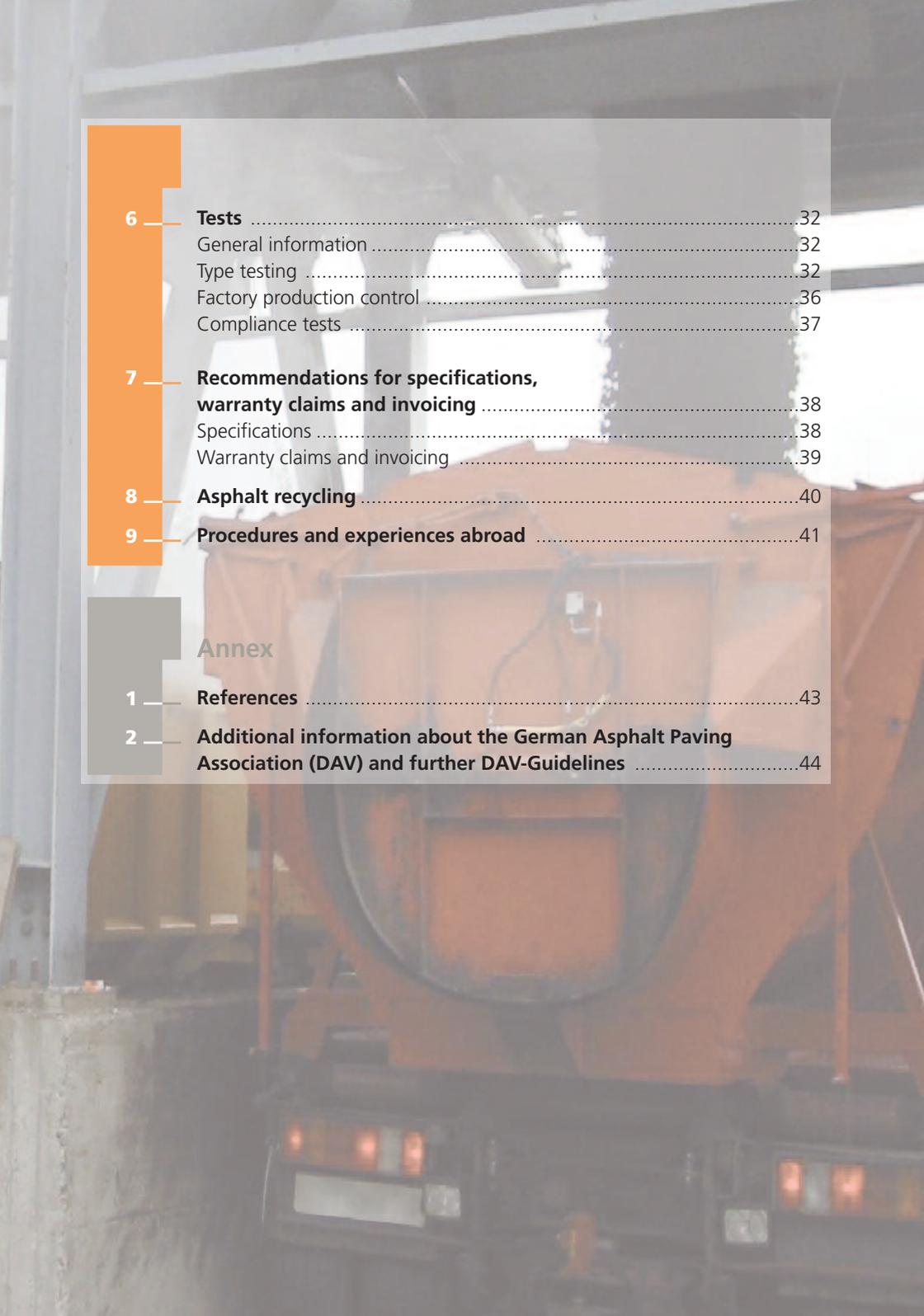
10/40-65 A

210 to 230 °C

Warm mix asphalt

Tips and tricks developed by professionals for professionals

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Introduction

During hot mix asphalt laying bitumen emits fumes and aerosols. Their concentration is determined by various factors such as the temperature of the asphalt. The higher the asphalt temperature, the higher the concentration of fumes and aerosols. For occupational health and safety reasons asphalt temperatures should be kept as low as possible during production and laying.

Reducing viscosity by adding organic and mineral additives has proven to be an easy and viable method to keep asphalt temperatures below the standard temperatures. Aside from temperature reductions, admixed additives can yield even more benefits, such as improved workability, higher deformation resistance, and the possibility to open the road to traffic after a shorter time period.



Introduction



These methods were designed originally for mastic asphalt (gussasphalt) floorings in buildings, because production and laying temperatures reach their highest values in this area. Since these methods have so many advantages they were soon used for mastic asphalt in road building and finally also for rolled asphalt.

In 2006 the German Road and Transportation Research Association (FGSV) published Guidelines for Warm Mix Asphalt [1] which describe various temperature reduction methods. The FGSV Guidelines are under review while these guidelines are being printed.

Based on these experience the guidelines in this brochure explain temperature reduction methods for rolled asphalt and mastic asphalt, highlight special aspects that are important for practical applications and give tips and tricks for asphalt mixture production and laying as well as for site management and testing.





At the beginning of 2008 the German committee for hazardous substances (Ausschuß für Gefahrstoffe) which reports to the Federal Minister of Labor and Social Affairs [2] cancelled the suspension of the threshold value of 10 mg/m³ for fume and aerosol emissions released from bitumen in hot mixes produced for mastic asphalt applications. Since then mastic asphalts may only be produced, supplied and laid at reduced temperatures below 230 °C. This method only works safely when adding viscosity modifying additives.

Mastic asphalt types addressed in these guidelines have an upper temperature limit of 230 °C. These types are used as wearing courses in road building as specified in TL-Asphalt StB 07 and ZTV Asphalt StB 07, as a waterproofing layer for bridge decks, and as interior flooring material.



1 Fundamentals

Basic principles

Benefits when using warm mix asphalts:

- **Bitumen releases less fumes and aerosols during hot mix processing**

Based on a rough estimate a 10 degree temperature decrease leads to a 50% emission reduction.



- **Energy savings and CO₂ emission reductions**

A temperature reduction of 30 degrees yields savings of 9 kWh of energy per ton of asphalt mix produced. This corresponds to 0.9 liters of heating oil per ton of asphalt mix. Accordingly, CO₂ emissions also drop.

Fundamentals



Basic principles

■ Improved deformation resistance

After having added viscosity modifying organic additives to reduce viscosity the deformation resistance of asphalt improves in warm to hot ambient temperatures.

■ Section can be opened to traffic at an earlier stage

Asphalts that are produced and laid with viscosity modifying organic additives and at reduced temperatures are ready-for-use within a shorter period of time.

■ Compaction aid

When using these asphalts at moderate or no temperature reductions their compactability improves significantly. This is especially advantageous when asphalts have to be laid by hand or during adverse weather conditions. The targeted degree of compaction can be achieved without fail and it is easier to lay thin layers.

■ Reduced susceptibility to aging of the binder

Lower production and laying temperatures reduce thermal aging of the binder.

Glossary

CO₂-emission

CO₂ mass that is emitted from a plant based on one ton of produced asphalt mix.

Water of crystallization

Water that is resident in a crystalline body. Normally, one or more water molecules are bonded to a substance molecule. The water in zeolites, however, is not part of the crystal lattice but resides on certain lattice sites. Water of crystallization is only loosely bound and is driven off by heat without changing the zeolite structure.

Temperature reduction

Producing and laying asphalt mixes at temperatures lower than the reference production temperatures for the asphalt mixture type.





Viscosity modifying mineral additives

Minerals (e.g. zeolite) containing physically or chemically bound water (e.g. water of crystallization) which are added to the asphalt mix during production to reduce mixing and laying temperatures.

Viscosity modifying organic additives

Substances that change the rheological properties of the binder in such a way that mixing and laying temperatures can be reduced.

Viscosity modifying binders

Binders whose rheological properties are changed by adding appropriate additives in such a way that mixing and laying temperatures can be reduced. Ready-for-use viscosity modifying binders are also described as ready-mix products.

Zeolites

Crystalline alkali silicate or alkaline-earth silicates containing water of crystallization that is consistently driven off by heat without changing the crystal structure. The silicates absorb other compounds instead of the released water and can also be used as ion exchangers.



2

Basic engineering concepts

Application

Basically all asphalt types and grades can be produced and laid at a reduced temperature and with modified viscosity. Using warm mix asphalt is essential for the following situations:

- Mastic asphalt
- Construction sites that can be closed off only for a short time (airport runways, construction work at night)
- Construction sites under adverse weather conditions (e.g. off-season)
- Traffic and industrial areas with special high loads

The specifications for asphalt mix design, base, and the asphalt layers set forth in the bulletins TL Asphalt-StB and ZTV Asphalt-StB also apply for warm mix asphalts. All these rules and regulations also apply for asphalt laying at reduced temperatures, excluding the sections governing binders and asphalt-mix temperatures.



3

Materials



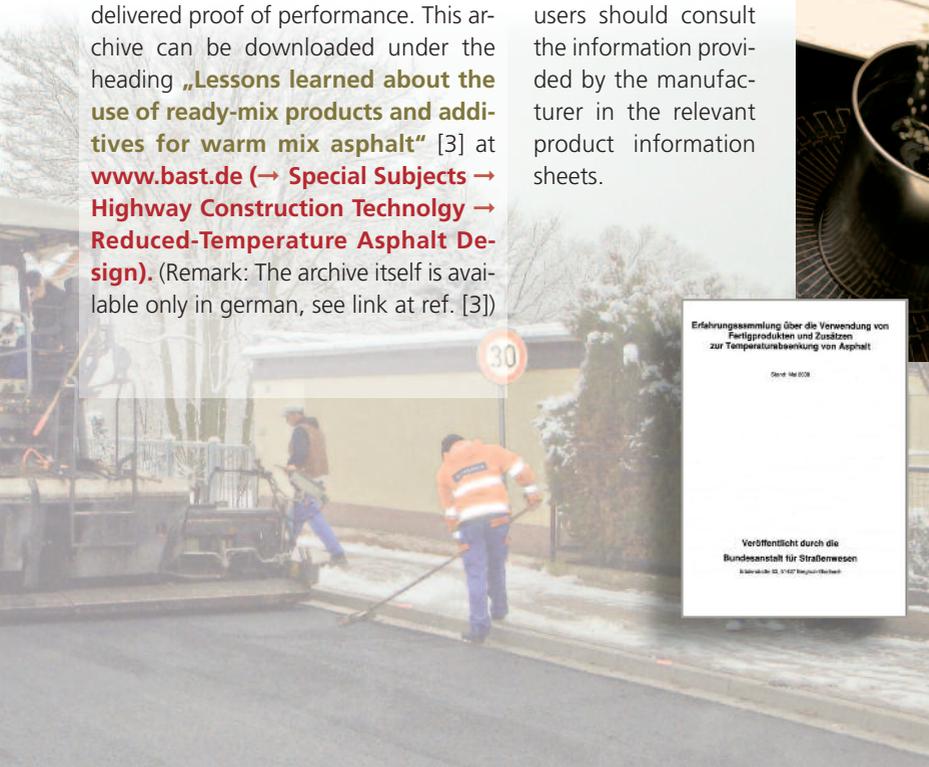
Binders and additives

Ready-to-use modified binders (“ready-mix products”) or additives of all sorts are supplied to produce warm mix/viscosity modified asphalts. There are viscosity modifying organic additives and viscosity modifying mineral additives.

The Federal Highway Research Institute (Bundesanstalt für Straßenwesen) archived experiences that include all viscosity modifying binders (ready-mix products) and viscosity modifying additives that delivered proof of performance. This archive can be downloaded under the heading **„Lessons learned about the use of ready-mix products and additives for warm mix asphalt”** [3] at www.bast.de (→ **Special Subjects** → **Highway Construction Technology** → **Reduced-Temperature Asphalt Design**). (Remark: The archive itself is available only in german, see link at ref. [3])

The ready-mix products consist of straight bitumen or polymer modified bitumen in accordance with TL Bitumen-StB and of viscosity modifying organic additives which will be described in detail. Additives have to be distributed homogeneously in the binder and should not impair the storage ability of the binders.

When handling such ready-mix products users should consult the information provided by the manufacturer in the relevant product information sheets.





Viscosity modifying organic additives

Viscosity modifying organic additives are either used to produce viscosity modified binders or are added during the asphalt-mixing process.

Ready-mix products are produced in special mixing plants and then shipped ready-for-use. This ensures a homogeneous distribution of the additive in the binder.

The viscosity modifying organic additives used so far can be separated into three different groups (Table 1).

Fischer-Tropsch waxes

Fischer-Tropsch paraffins are long-chain aliphatic hydrocarbons which are produced from syngas (carbon monoxide and hydrogen) under a high pressure catalytic process.

FT-molecules have a different chain-length than paraffins that are naturally found in mineral oil.

This explains why FT-paraffins have different physical properties and why they cannot be compared with naturally occurring bituminous waxes.

FT-paraffins are completely soluble in bitumen at temperatures above 115 °C. They form a homogeneous solution with base bitumen on stirring and produce a marked reduction in the bitumen's viscosity during its liquid state.

During cooling the FT-paraffins crystallize and form crystallites in the bitumen. This, in turn, increases asphalt stability and its deformation resistance.

Table 1

**Identification of substances –
viscosity modifying additives
and their effect
(e. g. using road bitumen 50/70)**

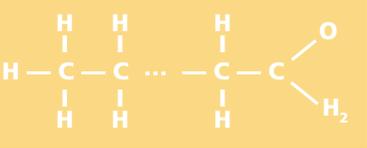
		Substance			
Name		Fischer-Tropsch waxes	Fatty acid amide (amide wax)	Montan wax	
Appearance		white powder or prills	white powder or prills	brown powder or prills	
Structure		Long-chain aliphatic hydrocarbons	Fatty acid diamide	Montanic-acid ester	
Properties	Drop point [°C]	114 to 120	140 to 145	110 to 140	
	Congealing point [°C]	100 to 105	135 to 142	100 to 130	
	Dynamic viscosity in mPas at	130 °C	11 to 15	not measurable	20 to 200
		140 °C	9 to 13	13 to 17	not determined
		150 °C	8 to 12	9 to 13	5 to 15
Effect in road bitumen 50/70	Additive [% by weight]	3,0*	3,0*	2,5 to 3,0*	
	Increase of R&B softening point [°C]	25 to 35	40 to 55	manufacturer's information	
	Decrease of needle penetration [1/10 mm]	15 to 25	10 to 15	manufacturer's information	
*) Percentage by weight of binder					



Fatty acid amides

Fatty acid amides are synthesized long-chain aliphatic hydrocarbons. Fatty acid amide molecules have a different chain-length than paraffins naturally found in mineral oil.

This explains why fatty acid amides have different physical properties and why these amides cannot be compared with naturally occurring bituminous waxes.



Fatty acid amides are completely soluble in bitumen at temperatures above 140 °C. When stirring the mix they form a homogeneous solution with the base bitumen and produce a marked reduction in the bitumen's viscosity during its liquid state.

During cooling the fatty acid amides crystallize and form crystallites in the bitumen, thus increasing asphalt stability and its deformation resistance.

Montan waxes

Montan waxes and their derivatives are obtained during lignite processing and consist of high-molecular hydrocarbons with a melting range from 110 to 140 °C.

This explains why Montan waxes have different physical properties and why they cannot be compared with naturally occurring bituminous waxes.

Above their melting range Montan waxes are completely soluble in bitumen. When stirring the mix they form a homogeneous solution with the base bitumen and produce a marked reduction in the bitumen's viscosity during its liquid state.

During cooling the Montan waxes crystallize and form crystallites in the bitumen, thus increasing asphalt stability and its deformation resistance.

Montan waxes can be added directly to the mixer which would require additional mixing time or into the mobile stirrer for mastic asphalt.





Viscosity modifying mineral additives

Natural and synthetic zeolites are used as viscosity modifying mineral additives. Zeolites are framework silicates with a porous structure that can accommodate and release foreign molecules without changing their own shape. They retain their shape and size.

In chemical engineering they are used as catalysts with a selective structure. Different pore sizes trigger different reactions. Only A-type-zeolites with a pore size from 2 to 5 Å ($1 \text{ \AA} = 10^{-10} \text{ m}$) are used in road building.

A-type-zeolites are only able to react to water because their active centers are inside the structure, i.e. they release and absorb water. This is why zeolites are also called molecular sieves.

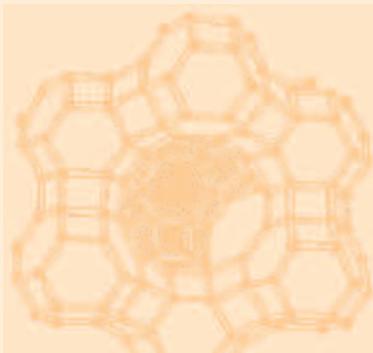


Table 2

Identification of substances – viscosity modifying mineral additives

Name	Zeolite
<p>Appearance</p>	<ul style="list-style-type: none"> ■ A-type-zeolites are sold as white powder or as powder with a yellowish dye. ■ Particle size distribution and density are used as characteristic values. ■ Their particle size distribution provides information as to how to handle and process zeolites. ■ Density provides information about the porosity of the structure.
<p>Structure</p>	<ul style="list-style-type: none"> ■ Three-dimensional framework silicates with highly porous structures, large voids or channels. ■ Their pore size ranges from 2 to 5 Å ($1 \text{ \AA} = 10^{-10} \text{ m}$). ■ Zeolites retain their shape and size.
<p>Properties/ effect</p>	<ul style="list-style-type: none"> ■ Zeolites can absorb foreign molecules into their structure and release them again without changing their own shape. ■ Zeolites do not react with their outer surface because all the active centers are located inside the pores and voids. ■ Water absorption and release are reversible and do not impact the aluminosilicate structure. ■ Natural and synthetic zeolites contain 6 to 12 % and up to 25 % water, respectively. ■ This water is selectively released at temperatures from 70 to 220 °C.

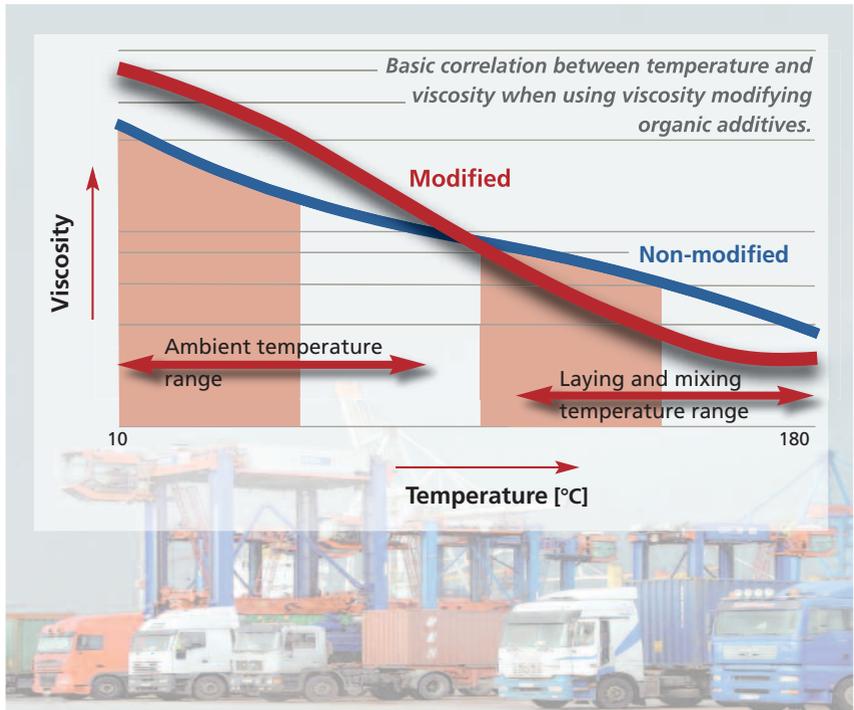


Effect

Viscosity modifying organic additives

Viscosity modifying organic additives (either as ready-mix or as admixture for an asphalt mixing plant) reduce binder viscosity at high temperatures and thus allow lower mixing and laying temperatures. At asphalt temperatures below the additive's congealing point this reduced viscosity is offset again or the effect is

even reversed (see picture below), i.e. the binder in the asphalt regains its original stiffness or is even stiffer than a comparable, conventional binder. This means that the binder now contributes more to the deformation resistance of the asphalt.



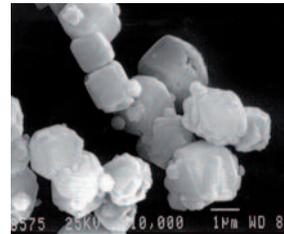


Viscosity modifying mineral additives

Typically, natural and synthetic zeolites are used as viscosity modifying mineral additives. Natural zeolites have 6 to 12 % of their mass entrapped as water in their crystalline structure and synthetic zeolites up to 25 %. This corresponds to 1 to 1.5 liters of water of crystallization per ton of asphalt.

Zeolites are added to the mix with the filler during mixing. As the mixing temperature increases the zeolites slowly release their absorbed water into the bitumen which is dispersed throughout the mixture in the form of very fine droplets. This leads to a marked reduction of the workable viscosity of the bitumen. The asphalt mix produced with this method can be laid even at lower temperatures without any problems.

As the asphalt and the binder cool off the fine mist condenses. The binder's viscosity regains its original level and the binder and the asphalt mix produced with the binder regain their original properties.



4

Asphalt mixtures

General information

Warm mix asphalts can be produced in normal asphalt mixing plants. Functioning exhaust stacks – at best even insulated – which ensure that exhaust temperatures are above the dew point even during low aggregate temperatures in the dryer drum are of essence for flawless production processes.

Adjusting the speed of the dryer drum might be helpful to reach the right aggregate temperature. The burner output and the dryer drum throughput have to be matched with the drum speed.



Pre-heaters for fillers have proven to work well when producing mastic asphalt because any asphalt mix temperature can be produced in an instant when cold and hot fillers are mixed.

Production temperatures and transportation times should be planned in a way that the reference temperatures for warm mix asphalt behind the screed specified in table 3 are kept.



Table 3**Reference values for asphalt mix temperatures when producing warm mix asphalts**

Asphalt type	Type and grade of binder	Reference temperatures for warm mix asphalt at production	Reference temperatures for warm mix asphalt behind screed
Rolled asphalt	70/100 50/70	130 to 150 °C	Minimum 120 °C
	30/45 25/55-55 A	140 to 160 °C	Minimum 130 °C
	10/40-65 A	150 to 170 °C	Minimum 140 °C
Mastic asphalt	30/45 20/30 25/55-55 A	200 to 230 °C	Minimum 200 °C Maximum 230 °C
	10/40-65 A	210 to 230 °C	Minimum 210 °C Maximum 230 °C

Empirical values for reduced mix temperatures for rolled asphalt when a transport vehicle with a normal canvas cover leaves the mixing plant and takes 30 minutes to reach the site are:

Outside temperature	Reduction
above 20 °C	15 to 30 degrees
10 to 20 °C	15 to 25 degrees
below 10 °C	0 to 15 degrees

The asphalt mixture temperature should not be reduced when temperatures are below 10 °C or during strong winds.

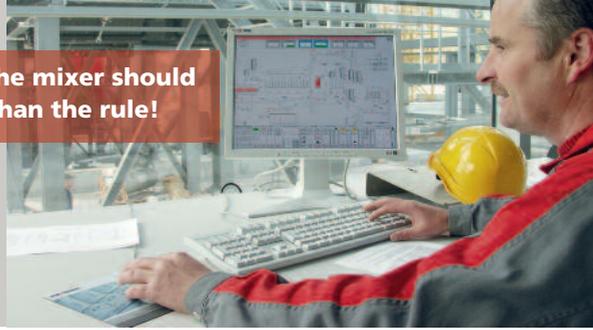


Asphalt mixtures

The following guidance is given for asphalt mixtures produced at reduced temperatures:

- Hopper doors might be difficult to open upon start of production because of lower temperatures.
- It is vital to set up a precise schedule for production, storage, transport and laying.
- The mixture should not be kept too long in the silo.
- Scope of possible temperature reduction depends on the weather (outside temperature, precipitation, wind etc.) which has a strong impact on laying.
- When setting the right temperature for the mixture keep in mind which asphalt mixture was produced in the last batch (it takes more time to reduce the mixing plant temperature than to increase it!) and/or whether the asphalt mixing plant has to be heated to the right „production temperature“.
- Aggregates should be as dry as possible to minimize water content in the emissions.
- Make sure that all the aggregate particles are entirely coated with binder. If necessary, extend the mixing period or change the addition sequence of components.
- For quality reasons you should not switch to asphalt mixture types/grades requiring standard production temperatures between mixing low-temperature batches.

Feeding additives into the mixer should be more the exception than the rule!



Admixture of viscosity modifying organic additives

Admixture as ready-mix product

Ready-mix products with viscosity modifying organic additives are available on the market for all sorts of different applications. They can be easily processed in standard batch plants and are handled the same way as standard road bitumen. It makes sense to lower storage temperatures in the bitumen storage tank to match viscosity. If necessary the time set for bitumen injection into the mixer has to be monitored and/or adjusted. You should follow the manufacturer's instructions.

Ready-mix products must have storage stability.

It is absolutely necessary that only one specific binder grade is charged into the tank. Even small amounts of other grades can change binder properties.

Ready-mix products should be the first choice to ensure consistent quality. When no ready-mix is used the mix can be modified at the asphalt mixing plant.

Introducing additives into the mixing chamber

Fischer-Tropsch-waxes and fatty acid amides have to be in a liquid state to ensure homogeneous distribution in the mix (mastix). This necessitates a change in the mixing sequence. A mastic has to be produced with a minimum binder content higher than 15 % by weight before blending in the additives and before the rest of the components are added. The fines and the filler components have to be metered in such a way that the total binder amount in the mixed batch yields a mastic with a binder content of at least 15 % by weight. Make sure that the mixing chamber has a filling rate of at least 35 % and that the mixer outlet is tight enough to prevent bitumen leakage. Remix for at least 15 seconds after introducing the additive. Only then are the remaining aggregates added to the mixer and the mix is agitated for another 15 seconds.

This modified production process increases the overall batch production time to 65 seconds. (The mix time does not have to be extended when using ready-mix products!)

Asphalt mixtures

Admixture of viscosity modifying organic additives

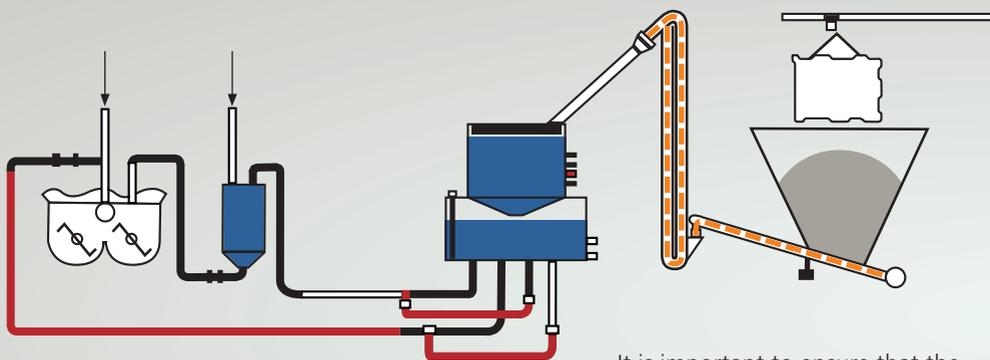
Simply incorporating the additives instead of modifying the production process as described above should be avoided, as extended mixing times cannot guarantee a perfect and homogeneous dispersion in the batch.

The additives can be introduced directly into the mobile stirrer when producing **mastic asphalt**. All additives should be added while the mobile stirrer is being filled. You will have to wait at least 60 minutes before placing the mixture.

Inline blending of additives

Additives can be blended with the bitumen stream at the asphalt mixing plant by using a **melting system** or an **ejector** for the introduction of solids into the bitumen stream.

After having passed through the **melting system** the molten additives are fed directly into the bitumen weigh bucket. The hot bitumen and liquid wax are blended and then pumped into the weigh hopper at the asphalt mixing plant, thus creating a viscosity modified binder.



Melting system – principle

It is important to ensure that the dosage of the relatively small quantities of additives is integrated into the process control of asphalt mixture production. This leads to a high degree of accuracy and allows a modification of all conventional bitumen grades and types.

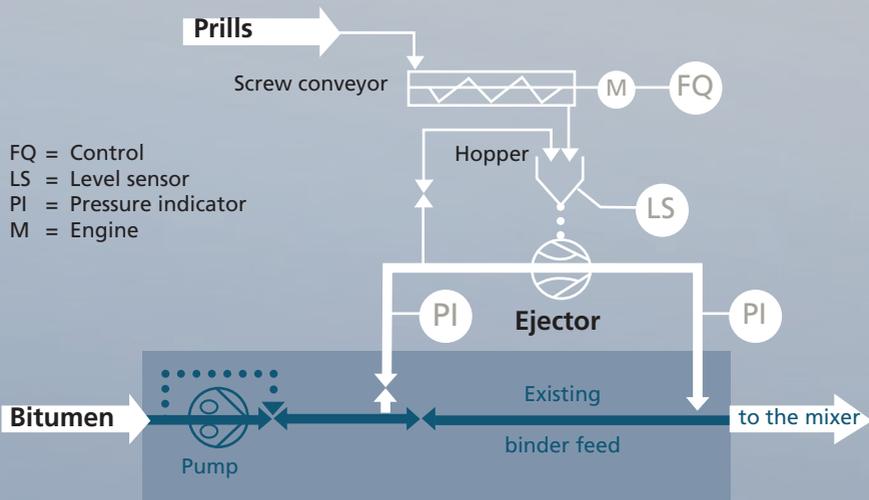
An **ejector** works like a water-jet pump.

The binder that is to be modified is pushed through a tapered section of the pipe. This creates a vacuum upstream of the tapered section. This vacuum can draw solid and liquid additives into the binder stream and thus allows their homogeneous distribution.

As the binder temperature is higher than the melting point of the additives the additives will melt and dissolve in the liquid phase of the binder.

The system bypasses the conventional binder feed to the scale. The admixture is added to the mix by volume which is based on the delivery rate of the binder and the additive. Addition rates may range from 2 to 12 % by mass of binder.

Ejector system – principle





Asphalt mixtures

Admixture of viscosity modifying organic additives

It is not necessary to extend mixing times for these two methods; the bitumen storage capacity at the asphalt mixing plant is not affected either. It is also very easy to produce small batches.

Admixture in combination with stabilizing additives

Modified fiber pellets are another option to introduce viscosity modifying additives into the mixer. Fiber pellets consisting of stabilizing additives (cellulose fibers) and viscosity modifying additives can be metered into the mix via the feed systems for stabilizing additives which are part of the asphalt plant.

When selecting fiber pellets and determining their quantity it is important to make sure that the amount of modified fiber pellets is carefully adjusted to match the binder content. This means that both the fibers and the wax must be proportioned accordingly. Mixing times are the same as recommended for regular stone mastic asphalt.



Admixture of viscosity modifying mineral additives

Zeolites are introduced directly into the mixer before the required binder quantity is added.

Zeolites come as a (synthetic) white or (natural) yellowish powder which can be used the same way as fillers.

In asphalt mix designs the amount of zeolites introduced into the mix needs to be accounted as filler .

An automatic feed system meters and feeds the zeolites from the silo into the plant. This method also works with a portable silo.

Small quantities can be added manually. The required amount comes in paper bags and is then added to the mixer.

Zeolites are introduced with the filler or after the filler was added. The mix has to be stirred at least for 5 seconds before adding the binder.

As with fibers, zeolites should be kept in a weatherproof and dry storage area.



Asphalt mixtures

Storing and hauling the asphalt mix

Rolled asphalt

Some basic guidelines should be considered when handling warm mixes:

- Temporary silo storage is possible for all warm mix asphalt types.
- For older silos keep in mind that temperatures will be lower at the discharge gates (gates may get sticky).
- The mixture should not be kept in the silo for an extended period of time.
- Usually transport vehicles do not need a release coating.
- Warm mix asphalt mixes should be hauled as quickly as possible to the job site.
- Avoid journeys that take longer than 60 minutes.

The following rule of thumb applies:

**Short journey =
lower asphalt mix
temperature**

**Long journey =
higher asphalt mix
temperature**

- Ensure that the mix is carefully and completely covered during transportation to avoid premature cooling of the asphalt mix, especially at the edges.
- Remove the cover (tarpaulin) only immediately before unloading.
- We recommended the use of insulated tipper bodies. Vehicles with thermal insulation ensure even greater efficiency.





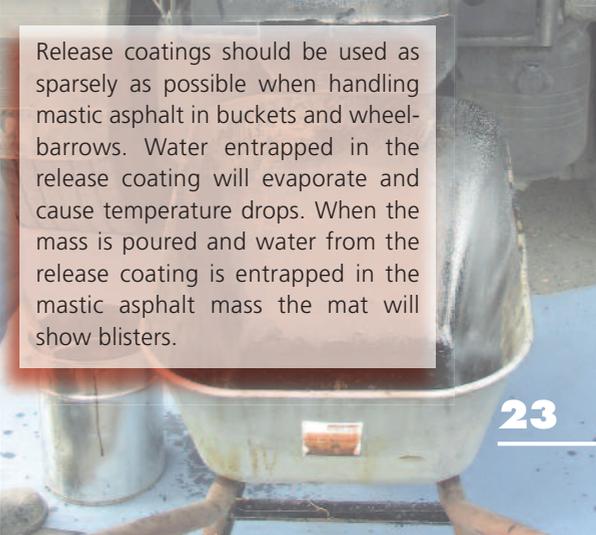
Mastic asphalt

Mobile stirrers are cauldrons that are used to ensure that the mastic asphalt mass is brought without any major changes and quality losses from the asphalt mixing plant to the job site, and to increase the degree of homogenization.

Viscosity modified mastic asphalt is hauled the same way as conventional mastic asphalt. Mobile stirrers work with horizontal or vertical agitators.

The following aspects should be considered when using a mobile stirrer:

- The asphalt mix must be homogeneous and its filling level above the measuring device to allow exact temperature readings.
- The temperature dial should be checked in regular intervals and should allow calibration to ensure that the reference temperatures are kept.
- Drivers must be informed that they are handling temperature-reduced mastic asphalt and that it is vital to keep the asphalt mix at the set temperature. Otherwise the mix might segregate and/or the binder might be damaged.
- Temperatures should be checked with a handheld thermometer (a probe thermometer is the best choice) during laying.
- Pursuant to Section 2.3.4. of the terms in ZTV Asphalt-StB 07 road bitumen may not remain longer than 12 hours in the stirrer and polymer-modified bitumen no longer 8 hours. In addition, the (actual) maximum retention time should be determined according to the varying temperatures and binders. Regulations do not allow the temperature to exceed 230 °C.



Release coatings should be used as sparsely as possible when handling mastic asphalt in buckets and wheelbarrows. Water entrapped in the release coating will evaporate and cause temperature drops. When the mass is poured and water from the release coating is entrapped in the mastic asphalt mass the mat will show blisters.



5 Laying

Preparing the job site

All parties involved in the warm mix site should be provided with detailed information about the pavement materials. When warm mix asphalts are laid for the first time it would make sense to ask engineers at the different bitumen and additive manufacturers for on site hands-on instructions.

Preparing the base

When working at lower asphalt temperatures the tack coats need to be applied very carefully and homogeneously to safeguard sufficient adhesion. The base has to be dry and clean.



Verdichten des Mischgutes

Walzeinsatz bei unterschiedlichen Asphaltarten

	ATS	AB1	AB	SMA	TDS	OPA	BSH	HTWA
Statische Dreieckswalze	+	+	+	++	-	+	++	-
Trommelwalze	ohne Vibration kleiner 6 Tonnen größer 6 Tonnen	+	+	++	-	+	++	-
	mit Vibration normal Oszillation	++	++	+	++	+	++	-

Excerpt from the DAV-guidelines „Tips and tricks for laying rolled asphalt“ (Available only in german)

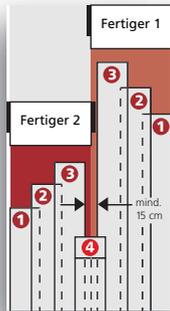
Laying of rolled asphalt

The production temperature has to be set to a level that ensures that the reference temperatures for warm mix asphalt behind the screed specified in Table 3 under Section 4 „Asphalt mixtures“ are met, taking due account of weather and transportation conditions.

Special reference is made to the **„Tips and tricks for laying rolled asphalt“** listed in the „Guidelines for rolled asphalt pavements“ of the German Asphalt Pavement Association, DAV (see Annex 2).

- ++ = besonders geeignet
- + = geeignet
- = bedingt geeignet
- = wenig geeignet

Walzverdichtung:
Variante 1



Variante 2

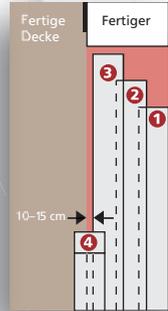


Table 4

Reference temperatures for warm mix rolled asphalts behind the screed

	Type and Grade of base binder	Reference temperatures for warm mix asphalt behind the screed
Rolled asphalt	70/100 50/70	Minimum 120 °C
	30/45 25/55-55 A	Minimum 130 °C
	10/40-65 A	Minimum 140 °C

Excerpt from Section 4, Table 3

Laying

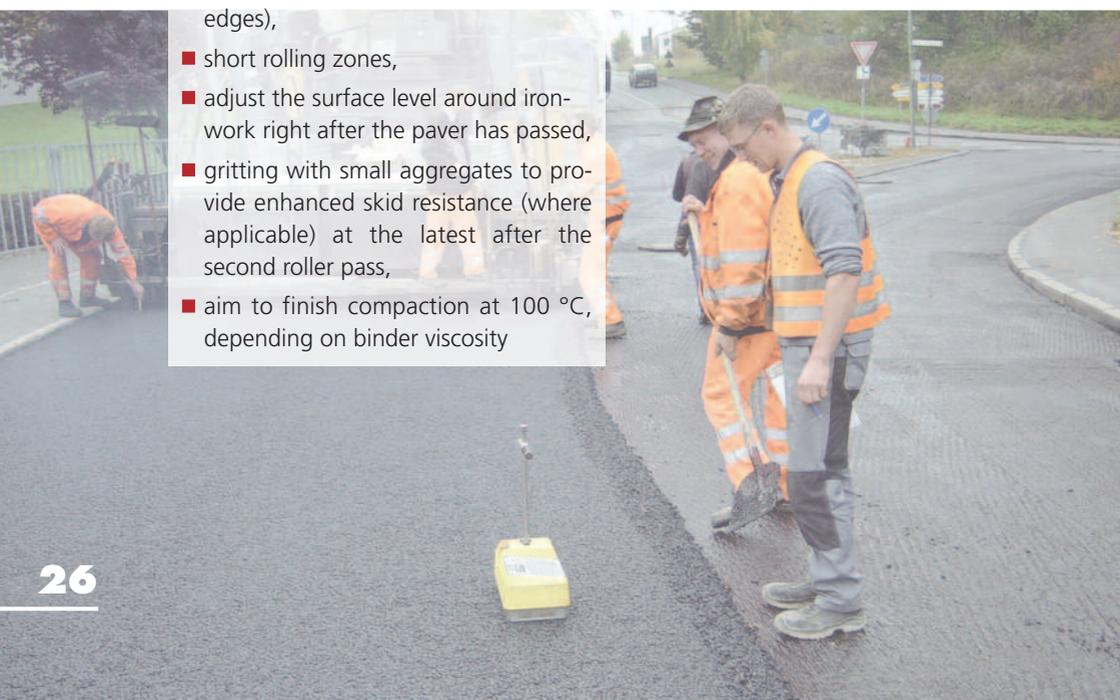


Laying technology has to be especially effective since there is only a small time window during which warm mix rolled asphalts can be laid. Therefore the following aspects should be kept in mind:

- Constant laying speed,
- continuous charging with mix,
- constant temperature control,
- rolling operations close to the paver,
- check the degree of compaction (e. g. with the density gauge),
- fast initial rolling (including the edges),
- short rolling zones,
- adjust the surface level around iron-work right after the paver has passed,
- gritting with small aggregates to provide enhanced skid resistance (where applicable) at the latest after the second roller pass,
- aim to finish compaction at 100 °C, depending on binder viscosity

When placing asphalt at lower temperatures there will be areas where the mat cools more quickly (edges, spandrels) as is the case with normal laying temperatures. Here, however, cooling will have a much greater impact because temperature levels are lower.

During adverse weather conditions and difficult laying conditions (city centers, trumpets, islands etc.) the time window can be extended by elevating the temperature.





Laying of mastic asphalt

The purpose of temperature-reduction methods for mastic asphalt described in this guideline is to ensure that the maximum temperature of 230 °C which has been in effect since January 2008 (see Introduction) and set forth in the bulletins TL Asphalt-StB 07 and ZTV Asphalt-StB 07 can be observed without sacrificing quality. Following are some recommendations as to how mastic asphalt should be handled and laid at a maximum temperature of 230 °C.

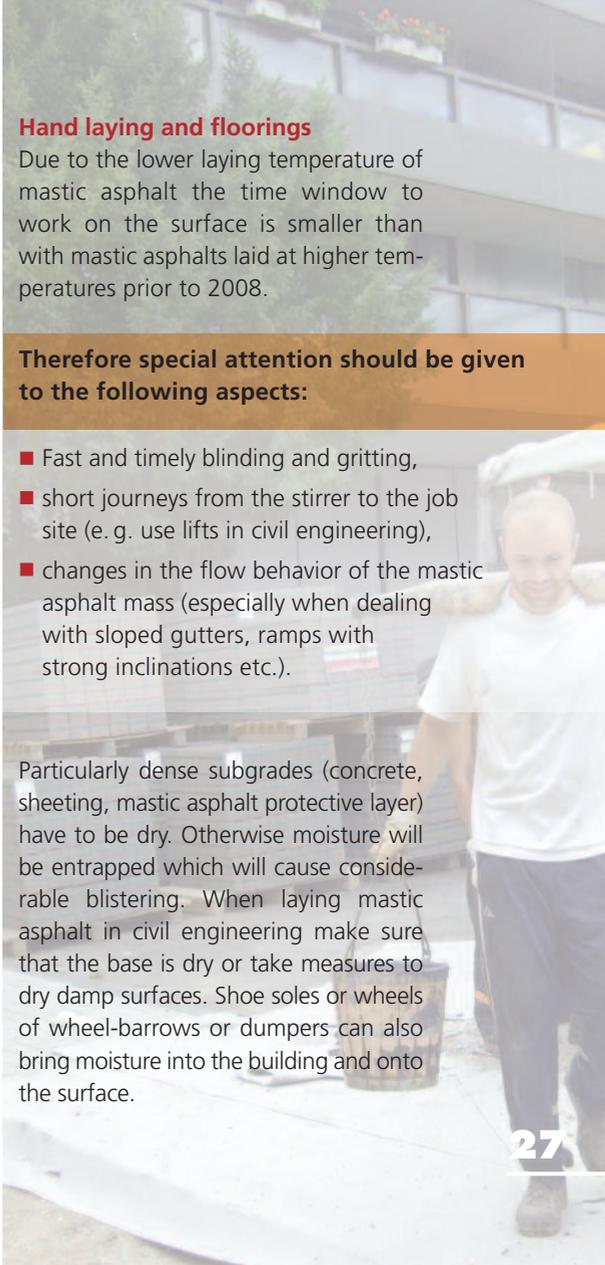
Hand laying and floorings

Due to the lower laying temperature of mastic asphalt the time window to work on the surface is smaller than with mastic asphalts laid at higher temperatures prior to 2008.

Therefore special attention should be given to the following aspects:

- Fast and timely blinding and gritting,
- short journeys from the stirrer to the job site (e. g. use lifts in civil engineering),
- changes in the flow behavior of the mastic asphalt mass (especially when dealing with sloped gutters, ramps with strong inclinations etc.).

Particularly dense subgrades (concrete, sheeting, mastic asphalt protective layer) have to be dry. Otherwise moisture will be entrapped which will cause considerable blistering. When laying mastic asphalt in civil engineering make sure that the base is dry or take measures to dry damp surfaces. Shoe soles or wheels of wheel-barrow or dumpers can also bring moisture into the building and onto the surface.



Laying



Laying by paver

Aspects to consider:

- The base must be clean and dry.
- Check the contact area of the screed unit.
- Mastic asphalt should not be laid too far ahead of the screed.
- Take into account rapid cooling of the edges.
- Level out the mastic asphalt mass with the spreading plough, also around the edges of the screed.
- Remove the entire cold material.
- Avoid that gritting chips are sunk into the material (due to lower viscosity).
- Ensure that the guide battens are in direct contact with the ground (the mastic asphalt mass might underflow the battens; sunken edges)
- When placing hot layers next to cold layers: Pre-heat the connecting surfaces with a heating system.
- Rolled mastic asphalt: Time the beginning of rolling so that the gritting particles cannot be fully pressed into the surface during initial rolling; on the other hand, ensure timely application of these aggregates in order for them to stay connected to the mastic film on the surface - even when it is windy!
- The gritting particles that are applied should be pre-heated. Supplying the aggregates in thermally insulated hoppers proved to work very well in the past. Poor adhesion due to aggregate particles that are too moist or too cold will cause insufficient skid resistance.
- Do not produce gritting particles during mastic asphalt production.





Improving workability

Weather conditions might require less temperature reductions or no temperature reductions at all. Lower viscosity of the binder allows better laying and compaction of the asphalt mix.

This advantage can be used for the following aspects:

- Hand-laid areas,
- unfavorable laying conditions (strong wind, low outside temperature, etc.),
- mixes that are difficult to compact,
- long hauls,
- thin layers paved with hot mixes.

Conditions and recommendations to consider:

- Compaction work of the paver screed has to be adjusted to the respective asphalt mix (asphalt base courses and asphalt binder courses need a higher degree of compaction).
- Normally, a high compaction screed is not necessary when placing surface course material.
- Initial rolling should be performed with medium weight rollers (6 to 8 t) without vibration.
- The second and subsequent compaction passes can be performed in the vibration or oscillation mode and with heavy rollers.
- When laying surface course materials compaction should preferably be carried out with static or oscillating rollers.
- Shoulders should be compacted only after the asphalt mat has reached a sufficient degree of deformation resistance and while it is still compactable.
- Gritting should be carried out after the second roller pass, if possible.



Release to traffic

Experience has shown that roads can be opened to traffic at an earlier stage when using additives. General conditions, such as air temperature, layer thickness etc. should be taken into account.

The following matters should also be addressed:

- The asphalt mix should be laid at the lowest possible temperature.
- Measure the temperature of the laid asphalt course on the surface and in the „core“.
- Use a density gauge to check the degree of compaction.
- If necessary, use signage after release to traffic: „Avoid tracking!“
- To ensure initial skid resistance we recommend that excess aggregates are swept off only after the road is opened to traffic and after the surface course has fully cooled.



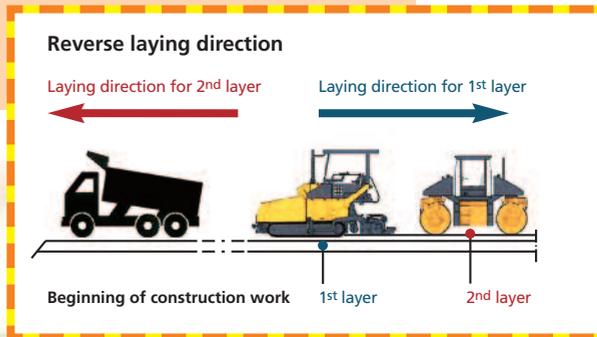


Site management

Appropriate site management has to ensure that asphalt materials with a warm mix design can be laid without any mistakes.

You should consider in particular the following aspects:

- Additional instructions for the paving crew,
- plan the job according to the material that is used,
- ensure constant asphalt mix supply that is adjusted to laying capacities,
- make available the right pavers and rollers,
- set up a detailed work flow plan, especially if the road has to be re-opened to traffic very quickly,
- have additional machines and staff on hold if the mix is laid simultaneously by hand and by paver at road junctions, bus bays, ironwork etc.,
- ensure that the same number of rollers is available as for conventional layings,
- revert the laying direction (see picture) when placing one layer immediately after another.



6

Tests

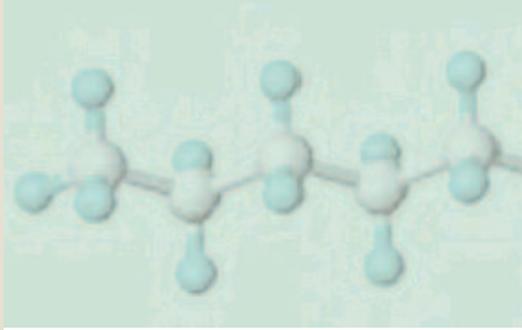
General information

Ensure that the relevant sections in the guidelines TL Asphalt-StB and ZTV Asphalt-StB are observed. The 2006 edition of the „Bulletin for warm mix asphalt“ (Merkblatt für Temperaturabsenkung von Asphalt“ - M TA) [1] is under review as these guidelines are being printed. The information in the revised bulletin will supersede these guidelines in the event of discrepancies.

Some viscosity modifying organic additives (e.g. fatty acid amides) interact with aggregate surfaces. This means that standard hot extraction will not guarantee full reclamation. In such cases



the ring and ball softening point is often lower than in the case of virgin viscosity modified binders. The manufacturers provide information as to how achieve a nearly full recovery of the additive.



Type testing

Asphalt mixes for warm mix asphalts (both rolled asphalt and mastic asphalt) are CE-marked – even if they fail to meet the guidelines in TL Asphalt-StB – because such mixes can be identified in the respective European material mix standards of the EN 13108 series.



When using grade designations (on delivery notes etc.) for warm mix for rolled asphalt make sure that you not only cite the (short) designation according to TL Asphalt-StB 07 but specify the characteristic of the warm mix, e.g. by using the abbreviation „TA“.



Type tests for asphalt mixtures with viscosity modified **organic additives** or viscosity modified binders are performed pursuant to TL Asphalt-STB 07. The suitability test has to be carried out again when the viscosity modifying organic additive or the viscosity modified binder (ready-mix) is changed. As a general rule, the ring and ball softening point of the viscosity modified binder in use has to be determined upon delivery and after extraction.



When carrying out the extractions the following extraction conditions should be uniformly set to minimize fluctuations caused by method variations:

- Washing cycles: 6
- Extraction time: 90 minutes
- Determination of the ring and ball softening point for the reclaimed binder.

The ring and ball softening point determined in this setting will be part of the contract and will serve as reference value for compliance tests.

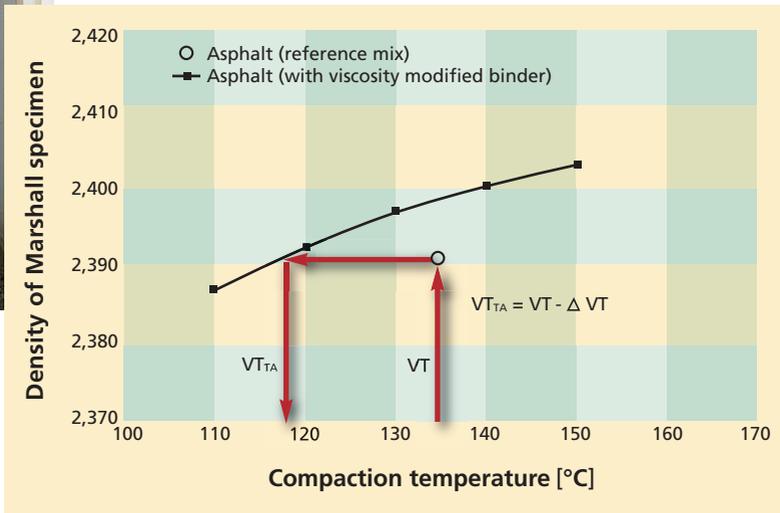
You should also be aware of the following aspects when conducting type tests for projects with reduced laying temperatures and if you have had no experience so far with viscosity modified asphalt mixtures.

Type testing

For rolled warm mix asphalt

Experience has shown that Marshall specimens required to determine density should not be produced at standard compaction temperatures of $135 \pm 5 \text{ }^\circ\text{C}$ (road bitumen) or $145 \pm 5 \text{ }^\circ\text{C}$ (polymer modified bitumen) when using asphalt mixtures that include viscosity modified binders and/or viscosity modifying organic additives.

The optimal asphalt mix composition and the reference density at compaction temperatures (VT) of $135 \text{ }^\circ\text{C}$ and $145 \text{ }^\circ\text{C}$ are determined by carrying out a reference test with a non-viscosity modified binder. Specimens for asphalt mixes manufactured with a viscosity modified binder or viscosity modifying organic additives should be produced at several different compaction temperatures (e. g. $110, 120, 130, 140,$ and $150 \text{ }^\circ\text{C}$) to determine the relevant temperature (VT_{TA}) for the production of specimens.





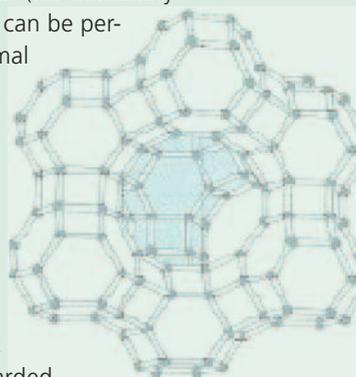
The temperature where the volumetric density and reference density match is the relevant compaction temperature which must be used to determine the reference density at the Marshall specimen during compliance testing. This rule also applies when using viscosity modified binders (ready-mix products) or viscosity modifying organic additives to improve workability/compactability, i. e. also during laying without temperature reduction.

So far practice has shown that the difference between reference compaction temperature and applicable compactability temperatures for warm mix asphalts does not cover the entire range of potential temperature reductions on site. Often it was possible to attain even greater temperature reductions on the job site.

Laboratory tests conducted with rolled asphalts treated with viscosity modifying **mineral additives** (zeolites) will not yield any specific results, since the effect of zeolites is limited by time and cannot be ascertained in the lab.

Zeolites do not change the ring and ball softening point of the binder. Therefore the softening point need not be determined and extractions (for suitability and compliance tests) can be performed with the normal extraction settings according to applicable rules and regulations.

In asphalt mix designs the amount of ad-mixed zeolites is accounted for as filler; zeolites are also regarded as filler in the testing procedure.



Annex 1 of the M TA [1] provides additional information on this matter.



Type testing

For mastic asphalt

Stirring resistance should be determined according to Annex 2 of the M TA [1] to qualify which effect temperature changes (temperature range from 180 to 230 °C). have on the workability of mastic asphalt. As these guidelines are printed development of a new stirrer is under discussion. (see picture on left).



Particularly when one or several components of the asphalt mix are changed (fine or coarse aggregates, fillers, binders, additives) it does make sense to (re-)determine the stirring resistance

The ring and ball softening point should be verified before and after the test to control if disproportionate binder hardening impacts the test results.

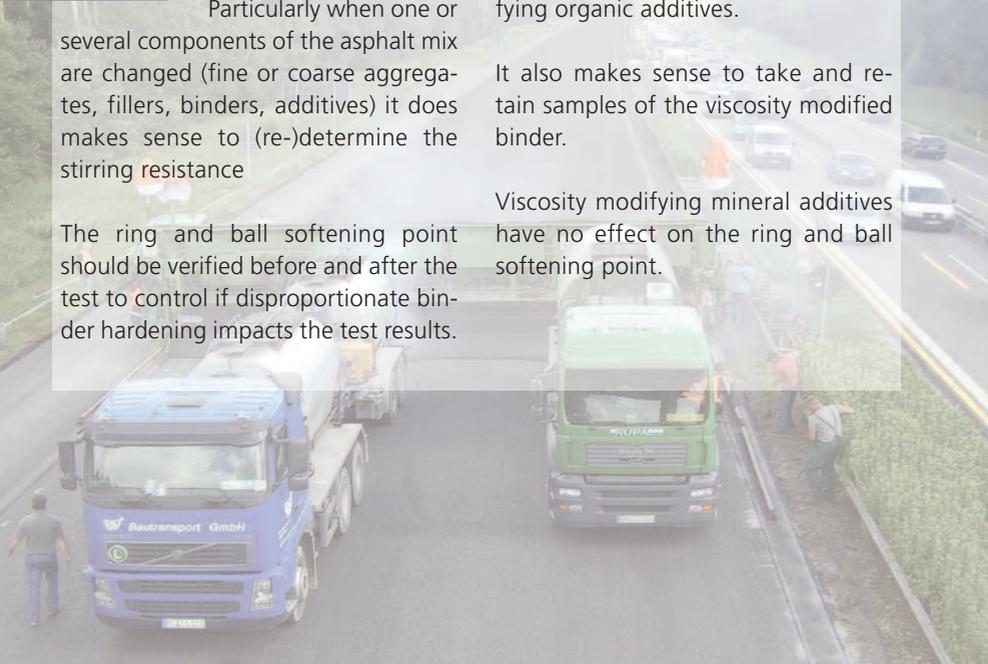
Factory production control

DIN EN 13108-21 is applicable for factory production control (FPC) at the asphalt mixing plant. Factory production control is carried out according to Section 4.2. of TL Asphalt-StB 07. Contractor's tests during laying are carried out according to Section 5.2 of ZTV Asphalt-StB 07.

The ring and ball softening point should be determined in regular intervals and compared with the results of the type test (see pp 32/33 in these guidelines) when using viscosity modifying organic additives.

It also makes sense to take and retain samples of the viscosity modified binder.

Viscosity modifying mineral additives have no effect on the ring and ball softening point.





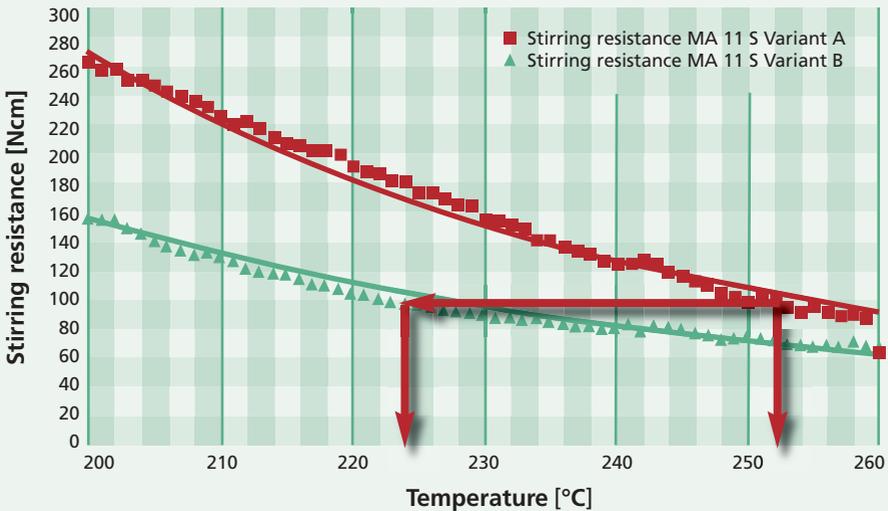
Compliance tests

Compliance tests should be carried out according to Section 5.3 of ZTV Asphalt-StB 07.

The ring and ball softening point of reclaimed bitumen determined in the type test is used as reference value to allow assessments against the contract terms.

This is the reason why identical testing conditions have to be ensured during compliance testing (see the extraction setting suggested on pp 32/33 etc.).

The relevant compaction temperature ascertained in the suitability test has to be used when producing Marshall specimens for the compliance test.



Mastic asphalt (variant B) produced with viscosity modifying organic additives has a markedly lower temperature but the same stirring resistance.

7

Recommendations for specifications, warranty claims and invoicing

Specifications

For specifying mastic asphalt you can copy the wordings in Section 113 „Asphalt designs“ of the (german) standard specification index to prepare



specifications for the production of mastic asphalt layers. These wordings already include text modules which describe the admixture of appropriate additives.

You should only use ready-mix products or additives according to the most recent version of “Lessons learned about the use of ready-mix products and additives for warm mix asphalt” [3]. These “Lessons learned” are available as download under www.bast.de (only in German, see page 7 of these guidelines)

The specifications must include type and grade of the required base binder. For rolled asphalts you are required to specify the use of ready-mix products or additives to be added to meet the main objectives of the construction project:



■ Objective: “Temperature reduction”:

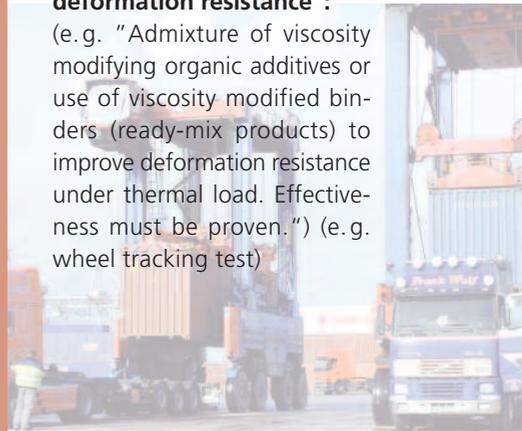
(e.g. “Temperature reduction by at least 20 degrees by adding viscosity modifying organic or viscosity modifying mineral additives or by using viscosity modified binders (ready-mix products).”)

■ Objective: “Improving workability/compactability”

(in special cases, e.g. where hand laying is necessary): (e.g. “Admixture of viscosity modifying organic or viscosity modifying mineral additives or use of viscosity modified binders (ready-mix products) to improve workability.”)

■ Objective: “Increasing deformation resistance”:

(e.g. “Admixture of viscosity modifying organic additives or use of viscosity modified binders (ready-mix products) to improve deformation resistance under thermal load. Effectiveness must be proven.”) (e.g. wheel tracking test)





■ **Objective: “Earlier release to traffic”:**

(e.g. “Admixture of viscosity modifying organic additives or use of viscosity modified binders (ready-mix products) to allow earlier release to traffic. Client and contractor will agree on site when the construction site will be opened to traffic.”)

You should be aware of the conditions specified in the “Type testing” section in these guidelines and cite these settings in the specifications; this also includes the extraction settings and the instructions regarding the temperature determination for the production of Marshall specimens for rolled asphalts.

When adding viscosity modifying organic and/or mineral additives at the asphalt mixing plant or to the mobile stirrer type and amount of additives used in the type test and intended for in-situ laying have to be documented (according to Section 2.3.2. of ZTV Asphalt-StB 07).

Production and laying temperatures should not be lowered when laying temperatures are below +10 °C or when considerable cools down of the mix is expected due to wind impact.

If an earlier release to traffic is stated as objective the contractor should select appropriate products to ensure that this goal can be attained.

Generally, the bidder should have built reference projects. If this is not the case the bidder should prove that his site manager and the paving crew are trained accordingly.

Warranty claims and invoicing

The provisions in the agreed rules and regulations (e.g. ZTV Asphalt-StB, ZTV BEA-StB) will apply.



8

Asphalt recycling



Experience has shown that RAP containing viscosity modifying organic or viscosity modifying mineral additives can be recycled without any problems.

The use of viscosity modifying organic additives leads to a marked increase in the ring and ball softening point. Therefore the ring and ball softening point is not an effective criterion to assess the

quality of such RAP. The suitability of the asphalt mix produced with this kind of RAP has to be verified in an initial type test.

When adding viscosity modifying mineral additives it seems that no special aspects have to be considered when recycling such asphalt because the binder does not change.



9

Procedures and experiences abroad

In addition to the viscosity modifying organic and mineral additives described in these guidelines there are even more technologies in use throughout the world:

- Admixture of chemical additives,
- Use of bitumen emulsions,
- Process technologies,
- Use of foamed bitumen.

These technologies are distinguished according to the following aspects:

- Hot mixes (hot mix at conventional temperatures),
- Warm mixes (temperature reduction by ca. 30 degrees),
- Half warm mixes (mixing and laying temperatures below 100 °C, mostly at around 90 °C) and
- Cold mixes (mixing and laying at ambient temperatures).

Process technologies often use specific addition sequences or the two-phase process.



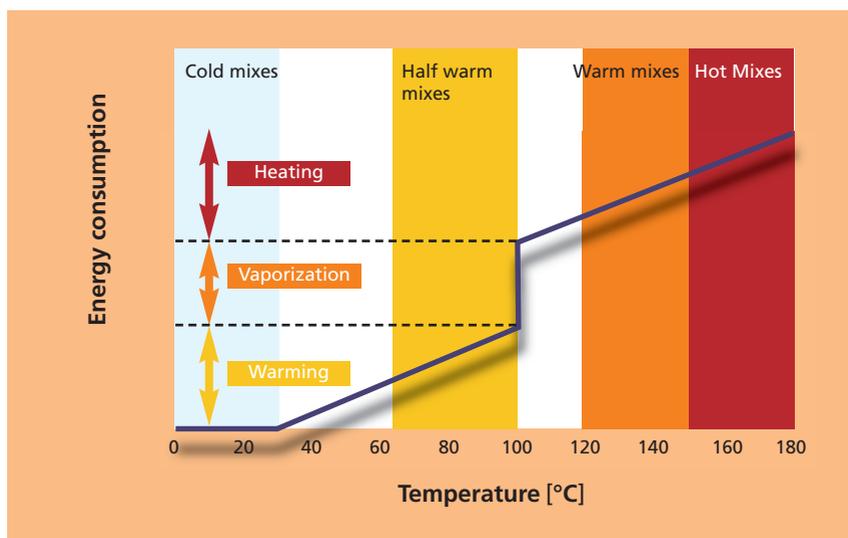
When following a specific sequence the coarse aggregates are charged into the mixer, bitumen is then added and mixed with the coarse aggregates. The fine aggregates and the filler are added in the last sequence.

When applying the two-phase process all aggregate sizes are fed into the mixer with the addition of a soft binder and mixed. A hard binder is added after this first mixing phase. The two combined binders thus yield the desired or required binder.

Some processes – which are mostly patent-protected – combine one of these process technologies with the foamed bitumen effect where bitumen is foamed with a conventional method or where the foaming effect is created by adding moist aggregates to the mix.



Procedures and Experiences abroad



Detailed overviews of these technologies can be found in the FHWA publication [4] or at the European Asphalt Pavement Association www.eapa.org [5].

The technologies and their designations – which are often connected to company names – are not listed here.

References

- [1] Merkblatt für Temperaturabsenkung von Asphalt (MTA), Ausgabe 2006.
FGSV Nr. 766 www.fgsv-verlag.de
-
- [2] Nur noch mit abgesenkter Temperatur, Reinhold Rühl, BG Bau und Obmann
des Gesprächskreises Bitumen. asphalt, Heft 4/2008 www.asphalt.de
→ Literatur)
-
- [3] Erfahrungssammlung über die Verwendung von Fertigprodukten und Zusätzen
zur Temperaturabsenkung von Asphalt, published by Bundesanstalt für Straßen-
wesen (BASt), Bergisch Gladbach www.bast.de → Fachthemen → Straßenbau-
technik → temperaturreduzierte Asphaltbauweisen → Erfahrungssammlung
or
[www.bast.de/cIn_005/nn_42746/DE/Aufgaben/abteilung-s/referat-s5/
temperaturreduzierter-asphalt/erfahrungssammlung.templateId=raw,
property=publicationFile.pdf/erfahrungssammlung.pdf](http://www.bast.de/cIn_005/nn_42746/DE/Aufgaben/abteilung-s/referat-s5/temperaturreduzierter-asphalt/erfahrungssammlung.templateId=raw,property=publicationFile.pdf/erfahrungssammlung.pdf).
Valid version when printing these guidelines: May 2008
(The archive is available only in german. For the english websites of BASt see
page 7 of these guidelines)
-
- [4] Warm mix asphalt: european practice. Publication no. FHWA-PL-08-007,
US Federal Highway Administration, February 2008
www.international.fhwa.dot.gov Fax: +1 202 366 9626)
-
- [5] The use of Warm Mix Asphalt – EAPA-Position Paper 2009. European Asphalt
Pavement Association, www.eapa.org

Additional information about the German Asphalt Paving Association (DAV) and further DAV-guidelines

More information about the German Asphalt Pavement Association DAV and the German Asphalt Research Institute DAI as well as an overview of their publications (brochures, guidelines and research reports) you will find on the internet:

www.asphalt.de

The screenshot shows the homepage of the German Asphalt Paving Association (DAV). At the top, there is a banner image of an airplane on a runway with the text "Herzlich Willkommen" (Warm Welcome) overlaid. To the right of the banner is the DAV logo, which consists of the word "asphalt" in a stylized font with green and red accents, and the tagline "FÜR ALLE FÜR ALLE". Below the banner is a navigation menu with the following items: Startseite, Deutscher Asphaltverband, Deutsches Asphaltinstitut, Aktuelles, Gesellschaft, Technik, Umwelt, Qualität, Literatur, Asphaltischwerke, Kontakte, Sonstiges, asphalt Shop, and Mitgliederbereich.

The main content area is divided into several sections. On the left, there is a grid of images showing various asphalt-related activities: a person riding a motorcycle, a person walking on a path, and a car driving on a road. To the right of these images is a text block that reads: "Herzlich Willkommen beim Deutschen Asphaltverband und Deutschen Asphaltinstitut. Der Deutsche Asphaltverband (DAV) e.V. ist die Interessenvertretung der deutschen Asphalt produzierenden und Asphalt verarbeitenden Industrie. Das Deutsche Asphaltinstitut (DAI) e.V. ist die Forschungseinrichtung der deutschen Asphaltindustrie. Neben Informationen zu DAV und DAI finden Sie auf dieser Seite viel Wissenswertes rund um den Baustoff Asphalt. Das Navigationsmenü dieser Internetauftritts ist am linken Seitenrand angeordnet. Rechts finden Sie auf dieser Seite aktuelle Meldungen sowie ggf. nach unten scrollen einen Link zum Verzeichnis der Asphaltischanlagen unserer Mitgliedsunternehmen".

On the right side of the page, there is a "News" section with the following items: "Investitionsprogramm 'Straßen' der BAB", "Neuer Leitfaden zum Thema Temperaturabgesenkte Asphalt", "Lärmreduzierung in Kommunen, Schulen, effektiv und wirtschaftlich mit Asphalt", and "Asphaltischwerke finden". Below these items is a map of Germany with various regions highlighted in different colors.

At the bottom of the page, there is a footer with the following text: "druck" (print), "webseiten" (websites), "dav" (Deutscher Asphaltverband), "dai" (Deutsches Asphaltinstitut), and "www.asphalt.de".

Notes

Notes

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