



# Stone Mastic Asphalt - SMA



# Specifications in Germany

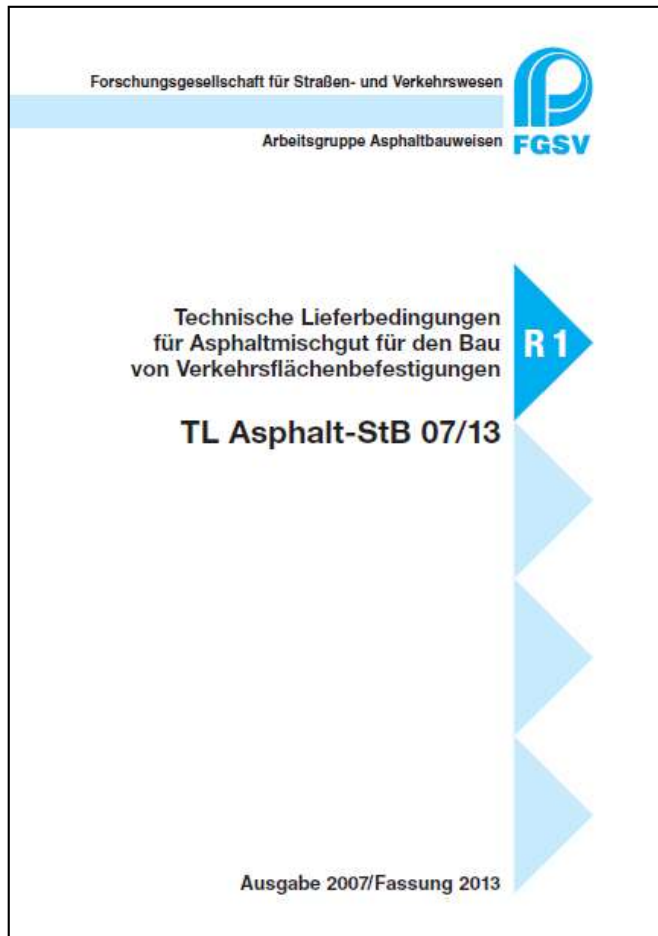
<p>DER BUNDES</p> <p>Zusätzlich</p> <p>bitum</p> <p>Z</p> <p><b>1984</b></p>	<p>BUNDES</p> <p>Zus</p> <p>Vertragsb</p> <p>von Fah</p> <p>ZTV</p> <p><b>1994</b></p>	<p>Forschungsgese</p> <p>Zus</p> <p>Vertragsb</p> <p>von Fah</p> <p>ZTV</p> <p>Änderu</p> <p><b>1998</b></p>	<p>Forschungsgesell</p> <p>Arbe</p> <p>Zusä</p> <p>Vertragsbed</p> <p>von Fahr</p> <p>ZTV</p> <p>mit Einarbeitung d</p> <p>ARS Nr. 28/200</p> <p>ARS Nr.</p> <p>ARS Nr.</p> <p><b>2001</b></p>	<p>Forschungsgesellschaft für Straßen- und Verkehrswesen</p> <p>Arbeitsgruppe Asphaltbauweisen</p> <p>FGSV</p> <p>Technische Lieferbedingungen für Asphaltmischgut für den Bau von Verkehrsflächenbefestigungen</p> <p>TL Asphalt-StB 07</p> <p><b>2007</b> Ausgabe 2007</p>	<p>Forschungsgesellschaft für Straßen- und Verkehrswesen</p> <p>Arbeitsgruppe Asphaltbauweisen</p> <p>FGSV</p> <p>Zusätzliche Technische Vertragsbedingungen und Richtlinien für den Bau von Verkehrsflächenbefestigungen aus Asphalt</p> <p>ZTV Asphalt-StB 07</p> <p><b>2007</b> Ausgabe 2007</p>
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# Specifications in Germany



**ZTV Asphalt-StB 07/13,  
German Additional Technical  
Conditions of Contract and  
Directives for the Construction of  
Road Asphalt Pavements,  
updated according to „ARS  
11/2012“ published by the Federal  
Ministry of Transport, Building  
and Urban Development**

# Specifications in Germany



**TL Asphalt-StB 07/13, German Technical Conditions of Delivery for Asphalt Mixtures for the Construction of Road Pavements, updated according to „ARS 11/2012“ published by the Federal Ministry of Transport, Building and Urban Development**

# Specifications in Germany

SMA		SMA 11 S	SMA 8 S	SMA 5 S <sup>1</sup>
<b>Materials</b>				
<b>Aggregates (production size)</b>				
Ratio crushed aggregate surface		$C_{100/0} : C_{95/1} : C_{90/1}$	$C_{100/0} : C_{95/1} : C_{90/1}$	$C_{100/0} : C_{95/1} : C_{90/1}$
Resistance to crushing		$Sz_{18} / LA_{20}$	$SZ_{18} / LA_{20}$	$SZ_{18} / LA_{20}$
Resistance to polishing		PSV <sub>specified</sub> (51)	PSV <sub>specified</sub> (51)	PSV <sub>specified</sub> (48)
Minimum part of fine aggregates with 0/2 E <sub>cs</sub> 35	%	100	100	100
Shape Index (SI)			20	
Flakiness Index (FI)			20	
Aggregate product size			G <sub>r</sub> 85; G <sub>c</sub> 90/10; G <sub>c</sub> 90/15	
Resistance to frost			F <sub>1</sub>	

<sup>1</sup> Source: Extract of ZTV BEA-StB 09, German Additional Technical Conditions of Contract and Directives for the constructional maintenance of Road Asphalt Pavements

Composition of Asphalt Mixture				
<b>Aggregate mixture</b>				
Passing sieve	16 mm	% by weight	100	
Passing sieve	11.2 mm	% by weight	90 – 100	100
Passing sieve	8 mm	% by weight	50 – 65	90 – 100
Passing sieve	5.6 mm	% by weight	35 – 45	35 – 55
Passing sieve	2 mm	% by weight	20 – 30	20 – 30
Passing sieve	0.063 mm	% by weight	8 – 12	8 – 12

# Specifications in Germany

Binder				
Binder, type and grade		25/55-55 50/70	25/55-55 50/70	45/80-50 50/70 25/55-55
Minimum binder content (factor $\alpha$ ) <sup>2</sup>		B <sub>min</sub> 6.7	B <sub>min</sub> 7.3	B <sub>min</sub> 7.4
Stabilizing additive (cellulose fibers)	% by weight	0.3	0.3	0.3
Asphalt Mixture				
Minimum void content Marshall-Specimen		V <sub>min</sub> 2.5	V <sub>min</sub> 2.5	V <sub>min</sub> 2.0
Maximum void content Marshall-Specimen		V <sub>max</sub> 3.0	V <sub>max</sub> 3.0	V <sub>max</sub> 3.0
Voids filled with bitumen	%	is to be specified	is to be specified	is to be specified
Proportional rut depth	%	is to be specified	is to be specified	—

<sup>2</sup> Factor  $\alpha$  considers the density of the aggregate mixture

Source: Extract of TL Asphalt-StB 07/13, German Technical Conditions of Delivery for Asphalt Mixtures for the Construction of Road Pavements, updated according to "ARS 11/2012" published by the Federal Ministry of Transport, Building and Urban Development

Characteristics of Layer				
Paving thickness	cm	3.5 - 4.0	3.5 - 4.0	1.5 - 2.0
Paving amount	kg/m <sup>2</sup>	85 - 100	85 - 100	30 - 50
Degree of compaction	%	≥ 98.0		≥ 96.0
Void content	Vol.-%	≤ 5.0		≤ 6.0
Gritting material		0.5 – 1.0 kg/m <sup>2</sup> aggregates 1/3 mm (dedusted or lightly bitumenized)		

Source: Extract of ZTV Asphalt-StB 07/13, German Additional Technical Conditions of Contract and Directives for the Construction of Road Asphalt Pavements, updated according to "ARS 11/2012" published by the Federal Ministry of Transport, Building and Urban Development

# Aggregate Requirements

SMA		SMA 11 S	SMA 8 S	SMA 5 S <sup>1</sup>
<b>Materials</b>				
Aggregates (production size)				
Ratio crushed aggregate surface		$C_{1000}^{\dagger} : C_{95/1}^{\dagger} : C_{90/1}^{\dagger}$	$C_{1000}^{\dagger} : C_{95/1}^{\dagger} : C_{90/1}^{\dagger}$	$C_{1000}^{\dagger} : C_{95/1}^{\dagger} : C_{90/1}^{\dagger}$
Resistance to crushing		$Sz_{18} / LA_{20}$	$SZ_{18} / LA_{20}$	$SZ_{18} / LA_{20}$
Resistance to polishing		PSV <sub>specified</sub> (51)	PSV <sub>specified</sub> (51)	PSV <sub>specified</sub> (48)
Minimum part of fine aggregates with 0/2 E <sub>cs</sub> 35	%	100	100	100
Shape Index (SI)			20	
Flakiness Index (FI)			20	
Aggregate product size			G <sub>f</sub> 85; G <sub>c</sub> 90/10; G <sub>c</sub> 90/15	
Resistance to frost			F <sub>1</sub>	

<sup>1</sup> Source: Extract of ZTV BEA-StB 09, German Additional Technical Conditions of Contract and Directives for the constructional maintenance of Road Asphalt Pavements



# Aggregate Requirements

Properties	Requirements	Main Influence on
Crushed Surface	$C_{100/0}$ (100% crushed surface)	Void content Stability
Hardness	$LA \leq 20$	No particle sizes' destruction during compaction
Resistance to Polishing	$PSV \geq 51$	Roughness Skid resistance
Shape Index	3:1 (min. 80%)	Void content Degree of filling Compaction degree Stability
Fines	$E_{CS} 35$	Void content Stability
Filler	Limestone	Void content
Oversize/Undersize	See separate chart	Void content Stability

# Aggregate Requirements

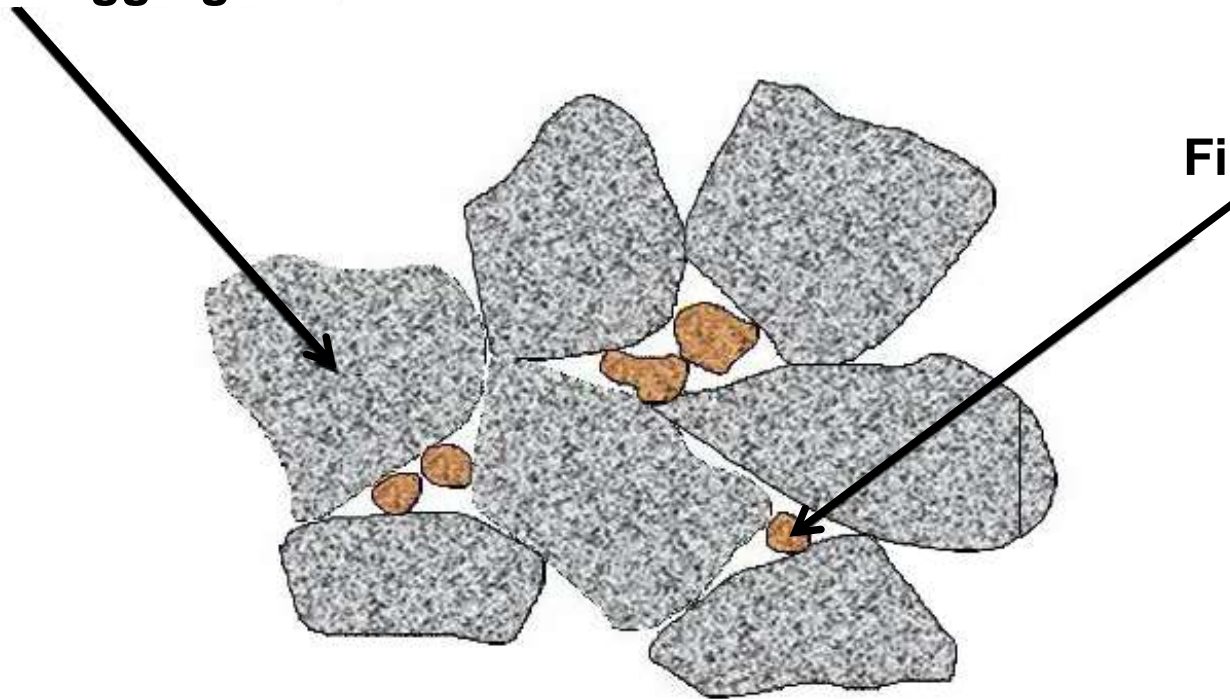
Fraction	Category	Oversize	Undersize
8.0 / 11.2 mm	G <sub>C</sub> 90/10	10 %	10 %
5.6 / 8.0 mm	G <sub>C</sub> 90/10	10 %	10 %
2.0 / 5.6 mm	G <sub>C</sub> 90/10	10 %	10 %
0.0 / 2.0 mm	G <sub>F</sub> 85	15 %	
1.0 / 3.0 mm*	G <sub>C</sub> 90/10	10 %	10 %

\* Gritting material for early life skid resistance

# Aggregate Requirements

## Good Coarse Aggregate Skeleton

Coarse Aggregate

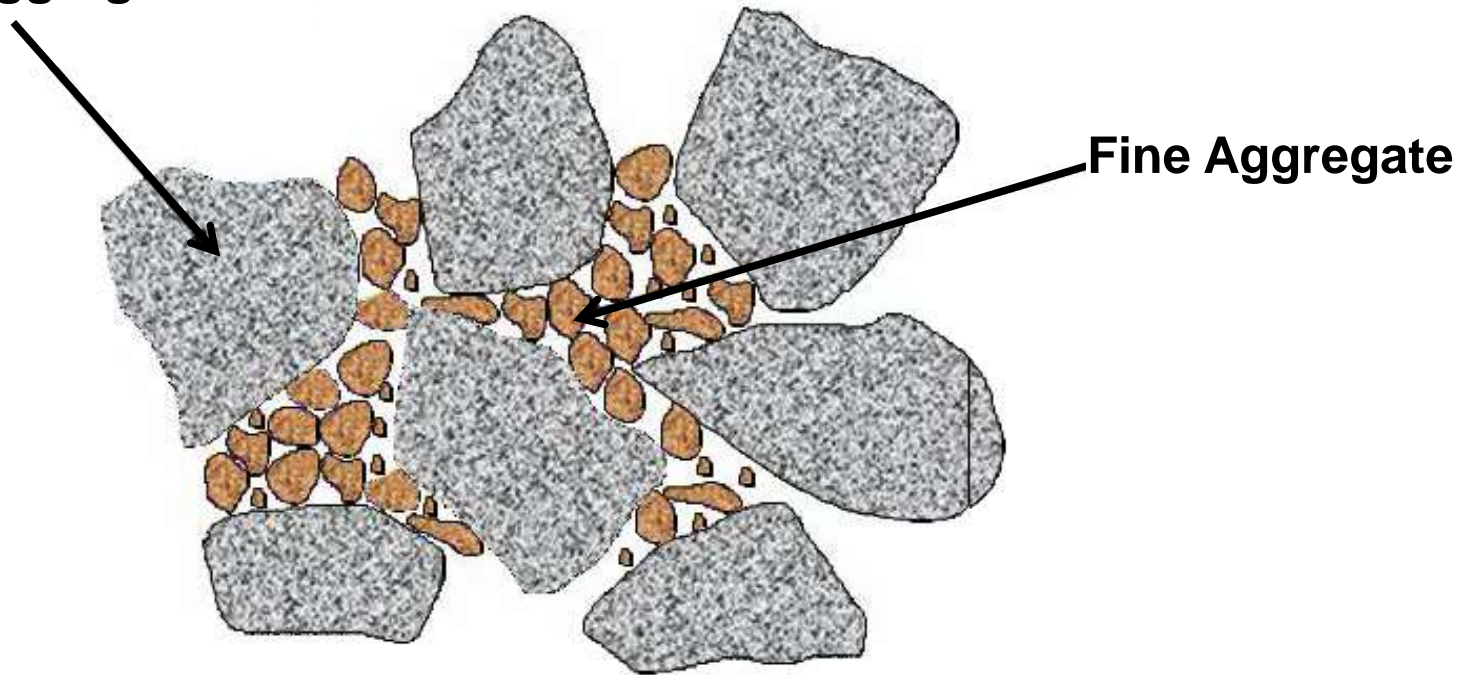


Fine Aggregate

# Aggregate Requirements

## Bad Coarse Aggregate Skeleton

Coarse Aggregate



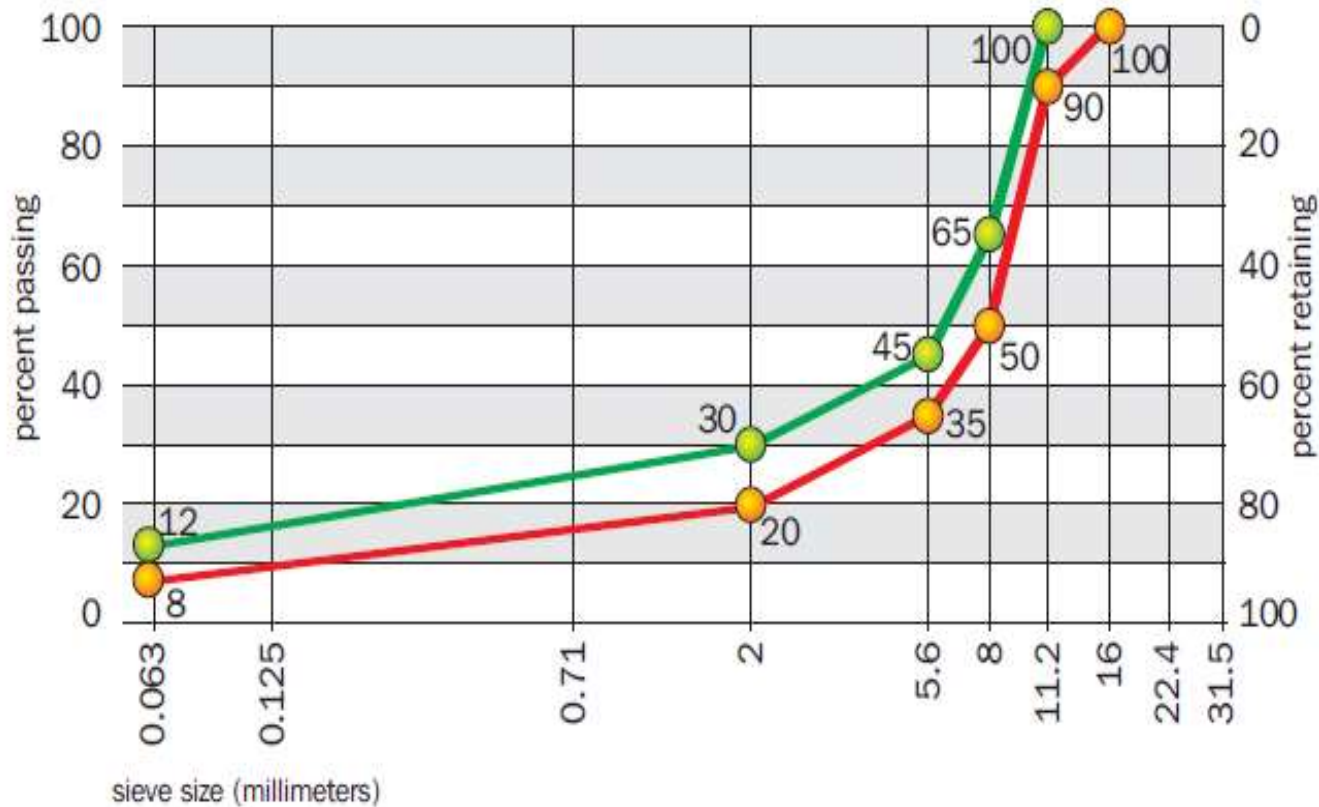
# Specifications in Germany

SMA			SMA 11 S	SMA 8 S	SMA 5 S <sup>1</sup>
<b>Composition of Asphalt Mixture</b>					
<b>Aggregate mixture</b>					
Passing sieve	16 mm	% by weight	100		
Passing sieve	11.2 mm	% by weight	90 – 100	100	
Passing sieve	8 mm	% by weight	50 – 65	90 – 100	100
Passing sieve	5.6 mm	% by weight	35 – 45	35 – 55	90 – 100
Passing sieve	2 mm	% by weight	20 – 30	20 – 30	30 – 40
Passing sieve	0.063 mm	% by weight	8 – 12	8 – 12	7 – 12

<sup>1</sup> Source: Extract of ZTV BEA-StB 09, German Additional Technical Conditions of Contract and Directives for the constructional maintenance of Road Asphalt Pavements

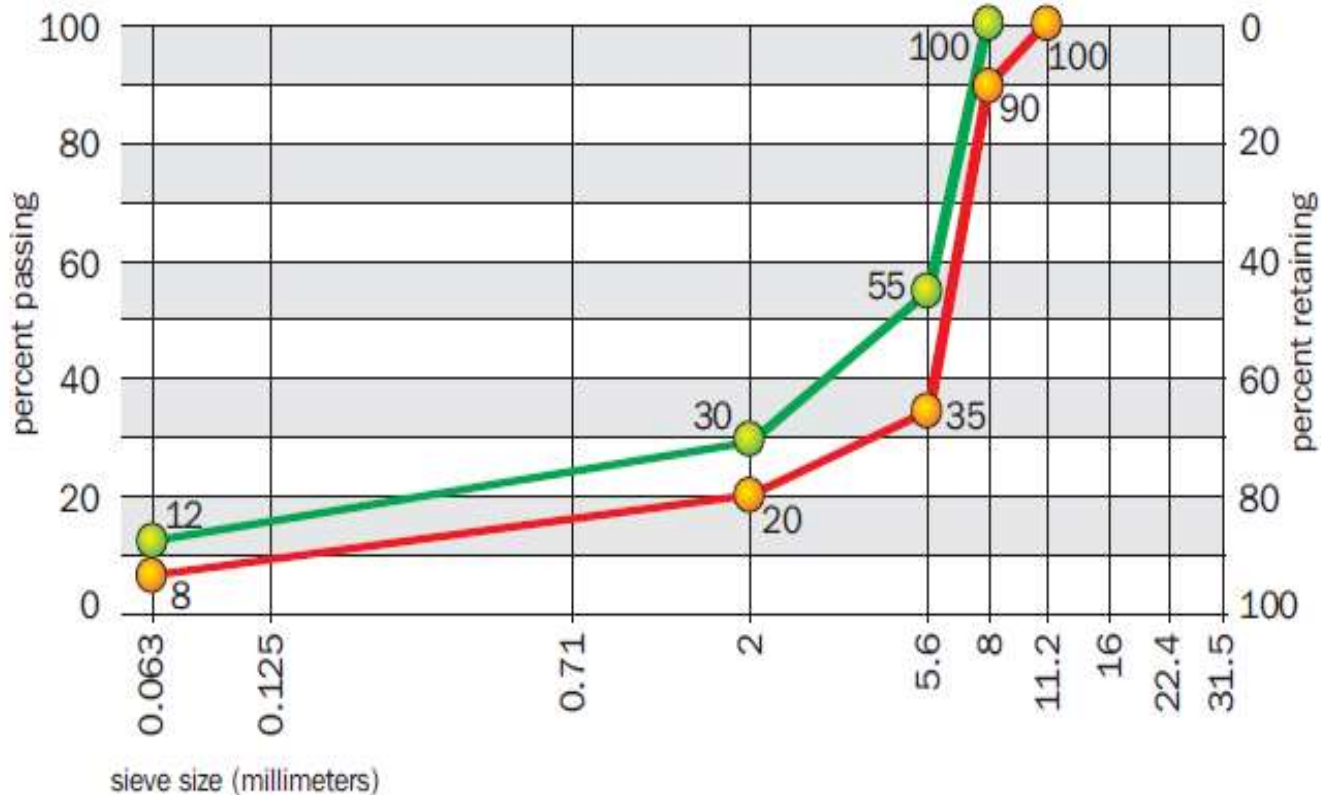
# Specifications in Germany

## SMA 11 S



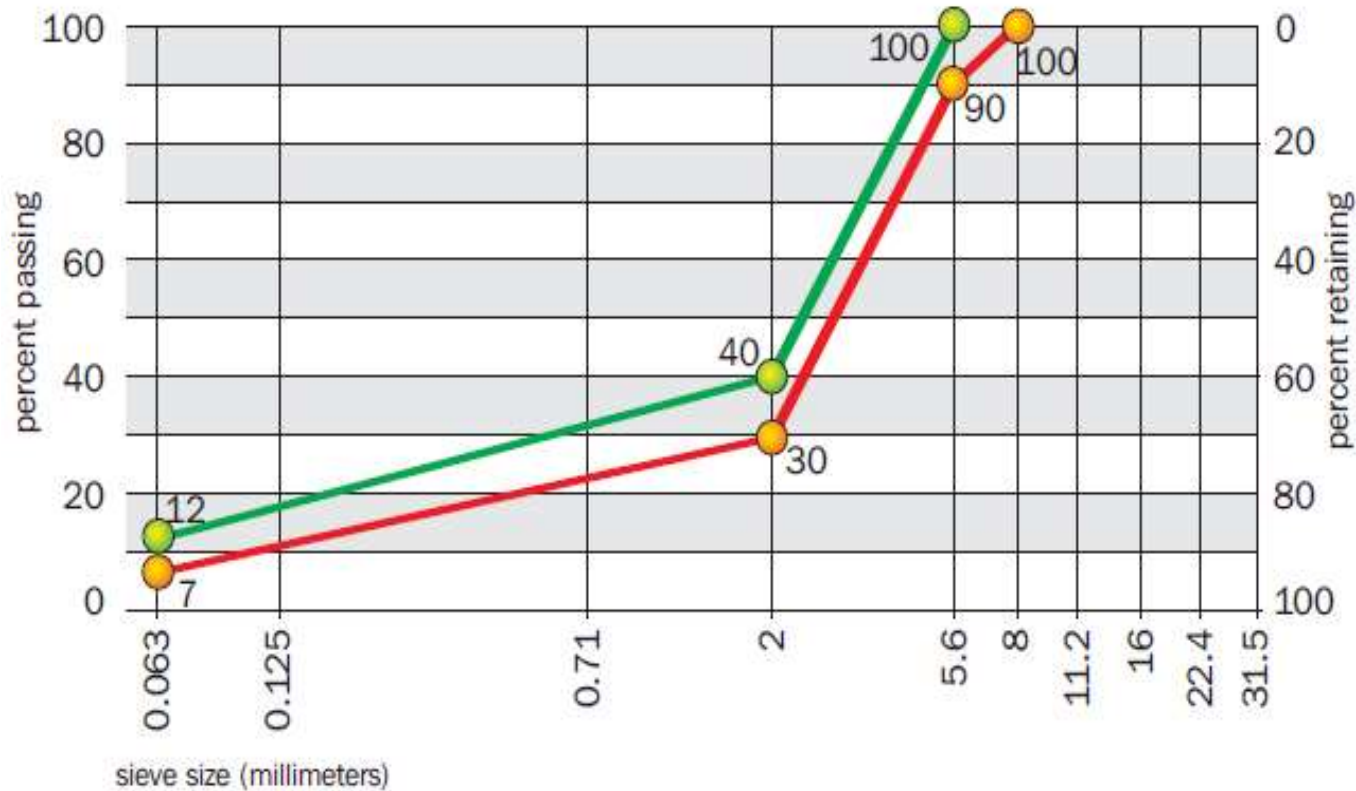
# Specifications in Germany

## SMA 8 S



# Specifications in Germany

## SMA 5 S





# Specifications in Germany

SMA		SMA 11 S	SMA 8 S	SMA 5 S <sup>1</sup>
Binder				
Binder, type and grade		25/55-55 50/70	25/55-55 50/70	45/80-50 50/70 25/55-55
Minimum binder content (factor $\alpha$ ) <sup>2</sup>		B <sub>min</sub> 6.7	B <sub>min</sub> 7.3	B <sub>min</sub> 7.4
Stabilizing additive (cellulose fibers)	% by weight	0.3	0.3	0.3

<sup>2</sup> Factor  $\alpha$  considers the density of the aggregate mixture

Source: Extract of TL Asphalt-StB 07/13, German Technical Conditions of Delivery for Asphalt Mixtures for the Construction of Road Pavements, updated according to "ARS 11/2012" published by the Federal Ministry of Transport, Building and Urban Development

Characteristics of Layer				
Paving thickness	cm	3.5 - 4.0	3.5 - 4.0	1.5 - 2.0
Paving amount	kg/m <sup>2</sup>	85 - 100	85 - 100	30 - 50
Degree of compaction	%	≥ 98.0		≥ 96.0
Void content	Vol.-%	≤ 5.0		≤ 6.0
Gritting material		0.5 – 1.0 kg/m <sup>2</sup> aggregates 1/3 mm (dedusted or lightly bitumenized)		

Source: Extract of ZTV Asphalt-StB 07/13, German Additional Technical Conditions of Contract and Directives for the Construction of Road Asphalt Pavements, updated according to "ARS 11/2012" published by the Federal Ministry of Transport, Building and Urban Development

# Specifications in Germany

SMA		SMA 11 S	SMA 8 S	SMA 5 S <sup>1</sup>
<b>Materials</b>				
Aggregates (production size)				
Ratio crushed aggregate surface		$C_{\text{crushed}} : C_{\text{total}} : C_{\text{min}}$	$C_{\text{crushed}} : C_{\text{total}} : C_{\text{min}}$	$C_{\text{crushed}} : C_{\text{total}} : C_{\text{min}}$
Resistance to crushing		$SZ_{10} / LA_{10}$	$SZ_{10} / LA_{10}$	$SZ_{10} / LA_{10}$
Resistance to polishing		PSV <sub>polished</sub> (51)	PSV <sub>polished</sub> (51)	PSV <sub>polished</sub> (48)
Minimum part of fine aggregates with 0,2 E <sub>50</sub> 35	%	100	100	100
Shape Index (SI)			20	
Flakiness Index (FI)			20	
Aggregate product size			G <sub>1</sub> 85; G <sub>2</sub> 90/10; G <sub>3</sub> 90/15	
Resistance to frost			F <sub>1</sub>	

<sup>1</sup>Source: Extract of ZTV BEA-StB 09, German Additional Technical Conditions of Contract and Directives for the constructional maintenance of Road Asphalt Pavements

<b>Composition of Asphalt Mixture</b>				
<b>Aggregate mixture</b>				
Passing sieve 16 mm	% by weight	100		
Passing sieve 11.2 mm	% by weight	90 - 100	100	
Passing sieve 8 mm	% by weight	50 - 65	90 - 100	100
Passing sieve 5.6 mm	% by weight	35 - 45	35 - 55	90 - 100
Passing sieve 2 mm	% by weight	20 - 30	20 - 30	30 - 40
Passing sieve 0.063 mm	% by weight	8 - 12	8 - 12	7 - 12
<b>Binder</b>				
Binder, type and grade		25/55-55 50/70	25/55-55 50/70	45/80-50 50/70 25/55-55
Minimum binder content (factor α) <sup>1</sup>		B <sub>min</sub> 6.7	B <sub>min</sub> 7.3	B <sub>min</sub> 7.4
Stabilizing additive (cellulose fibers)	% by weight	0.3	0.3	0.3
<b>Asphalt Mixture</b>				
Minimum void content Marshall-Specimen		V <sub>min</sub> 2.5	V <sub>min</sub> 2.5	V <sub>min</sub> 2.0
Maximum void content Marshall-Specimen		V <sub>max</sub> 3.0	V <sub>max</sub> 3.0	V <sub>max</sub> 3.0
Voids filled with bitumen	%	is to be specified	is to be specified	is to be specified
Proportional rut depth	%	is to be specified	is to be specified	—

<sup>1</sup>Factor α considers the density of the aggregate mixture

Source: Extract of TL Asphalt-StB 07/13, German Technical Conditions of Delivery for Asphalt Mixtures for the Construction of Road Pavements, updated according to "ARS 11/2012" published by the Federal Ministry of Transport, Building and Urban Development

# Paving and Compaction - Gritting



**Chippings 1 to 3 mm**  
**0.5 – 1.0 kg/m<sup>2</sup>**



# Applications



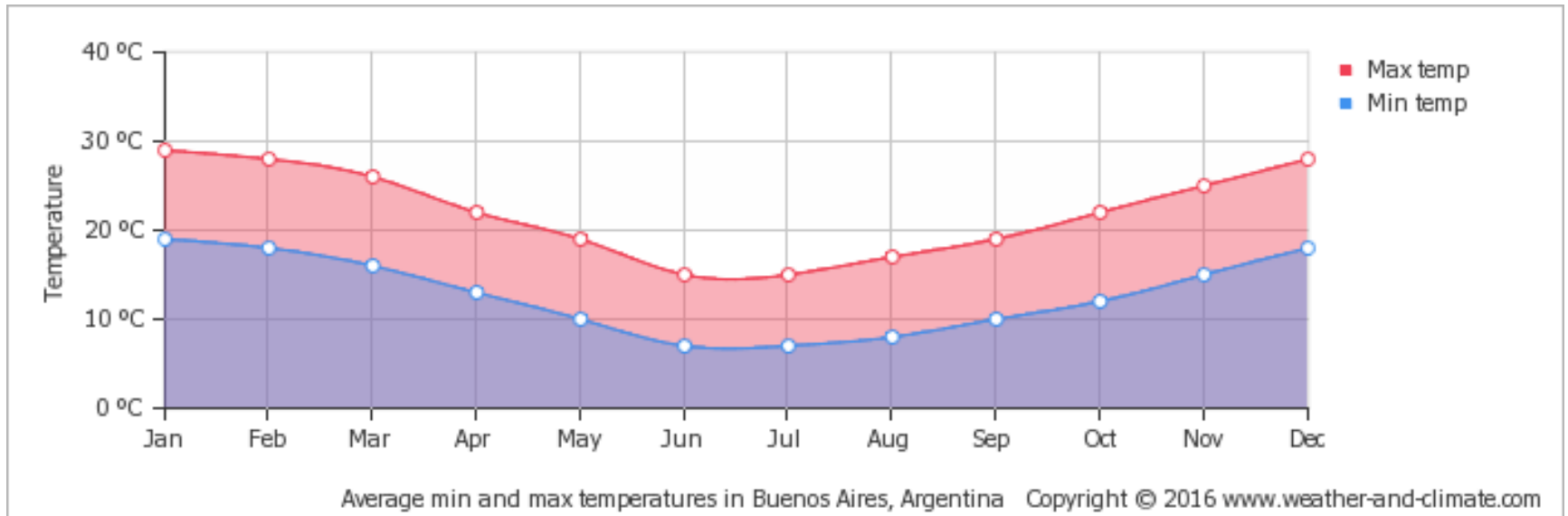
Argentina

# Applications



Argentina

# Argentina

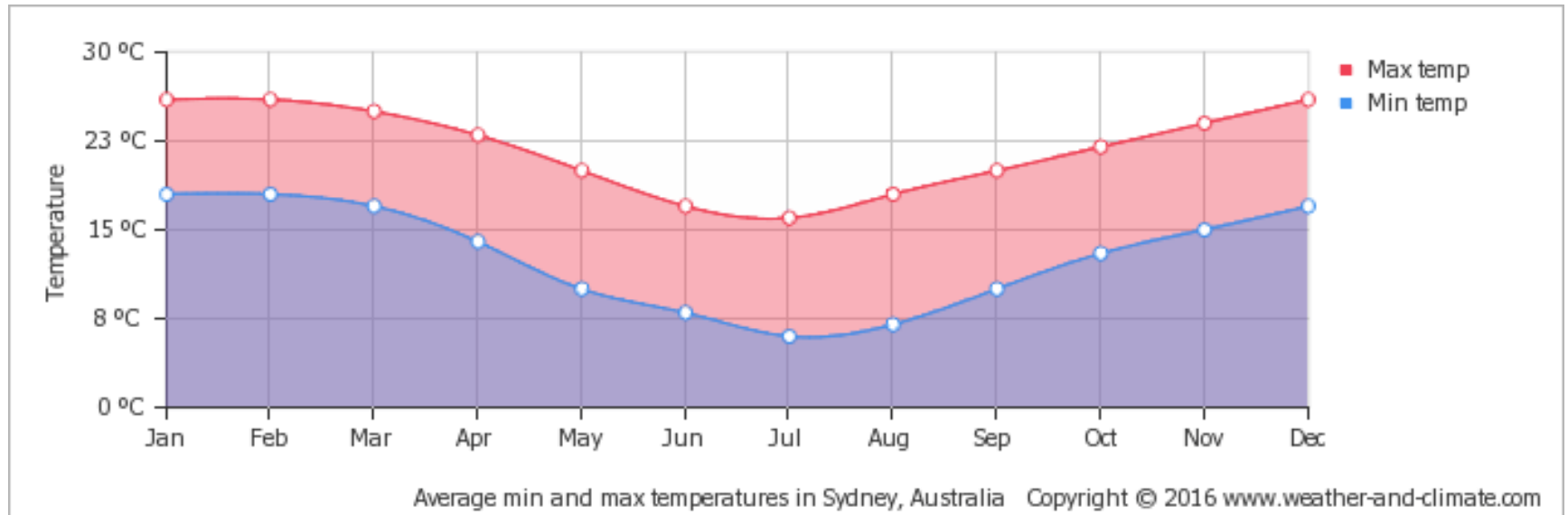


# Applications



Australia

# Australia





# Applications



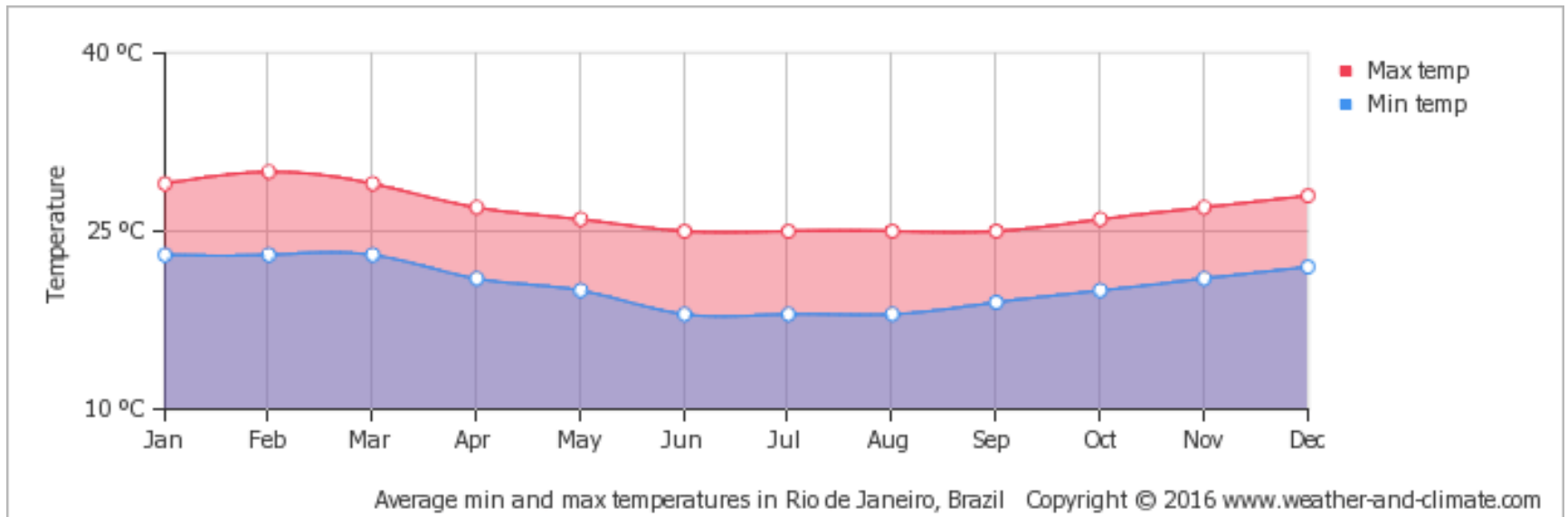
Brazil

# Applications



Brazil

# Brazil



# Applications



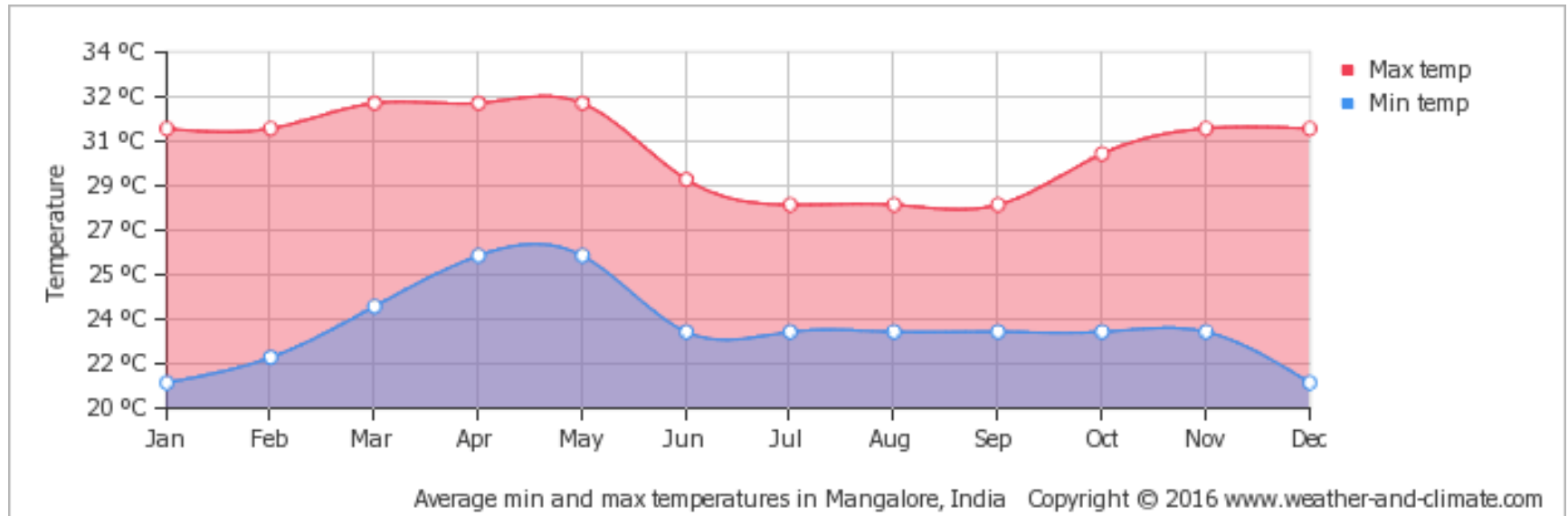
India

# Applications



India

# India



# Applications



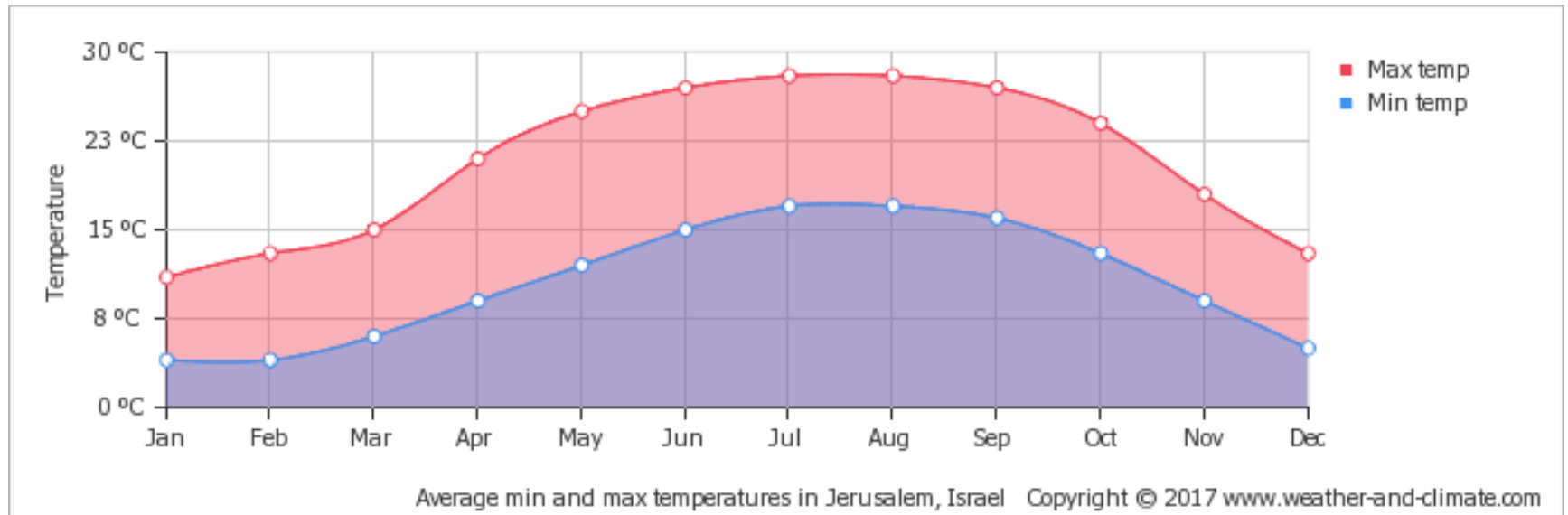
Israel

# Applications





# Israel



# Applications



Korea

# Applications



Korea

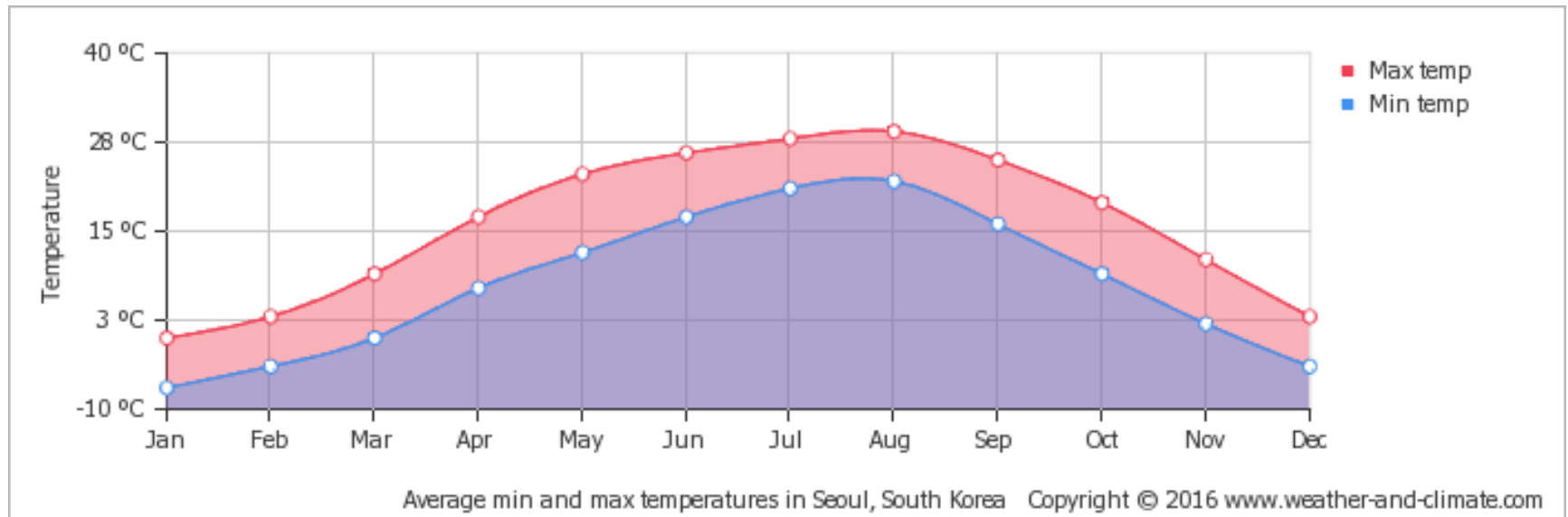
# Applications

For road construction engineers, connections between two islands separated by saltwater have always been a big challenge. Careful and sophisticated planning is essential, as is choosing the best material to ensure that this connection is long lasting and safe.

In Korea, the engineers who designed the Seohae Grand Bridge which connects the island of Pyongtaek (Gyeonggi-do) with Dangjin (Chungcheongnam-do) at mainland South Korea, conducted extensive studies, and finally decided to use SMA with **VIATOP**<sup>®</sup> as the best solution for the surface layer for this important connection.

Today, after 16 years in service they have received confirmation that their decision was the correct one, as the surface layer of SMA with **VIATOP**<sup>®</sup> is still there, and still offers an excellent performance.

# Korea



# Applications



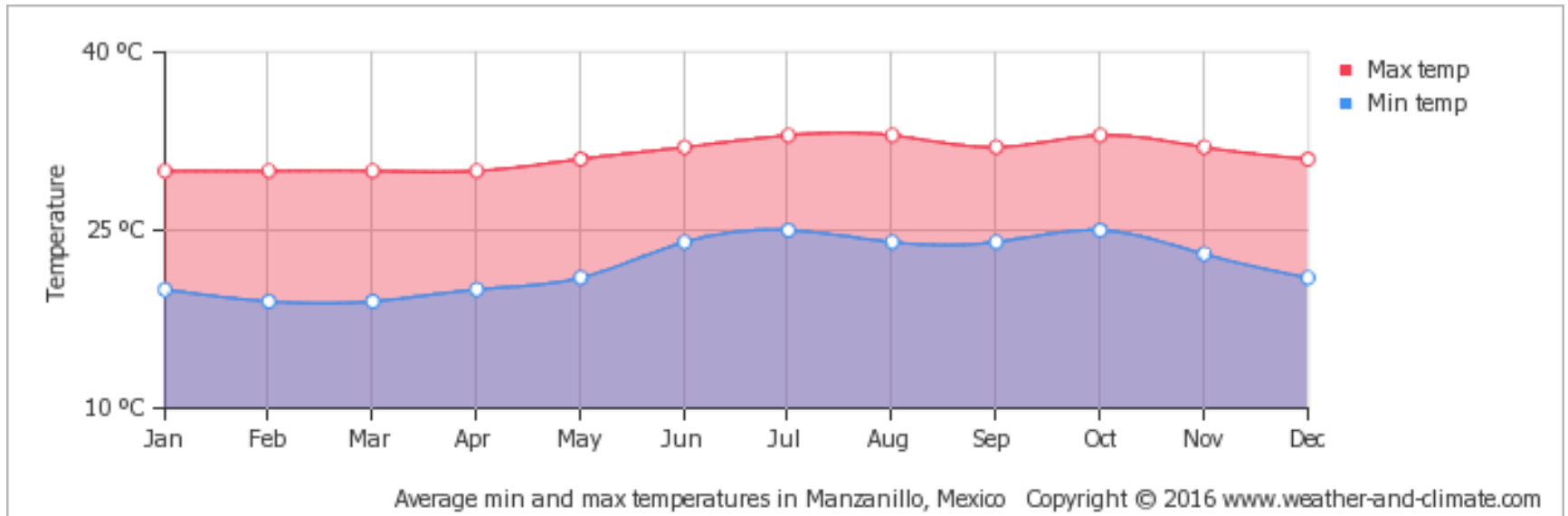
Mexico

# Applications



Mexico

# Mexico





# Applications



Philippines

# Applications



Philippines

# Applications



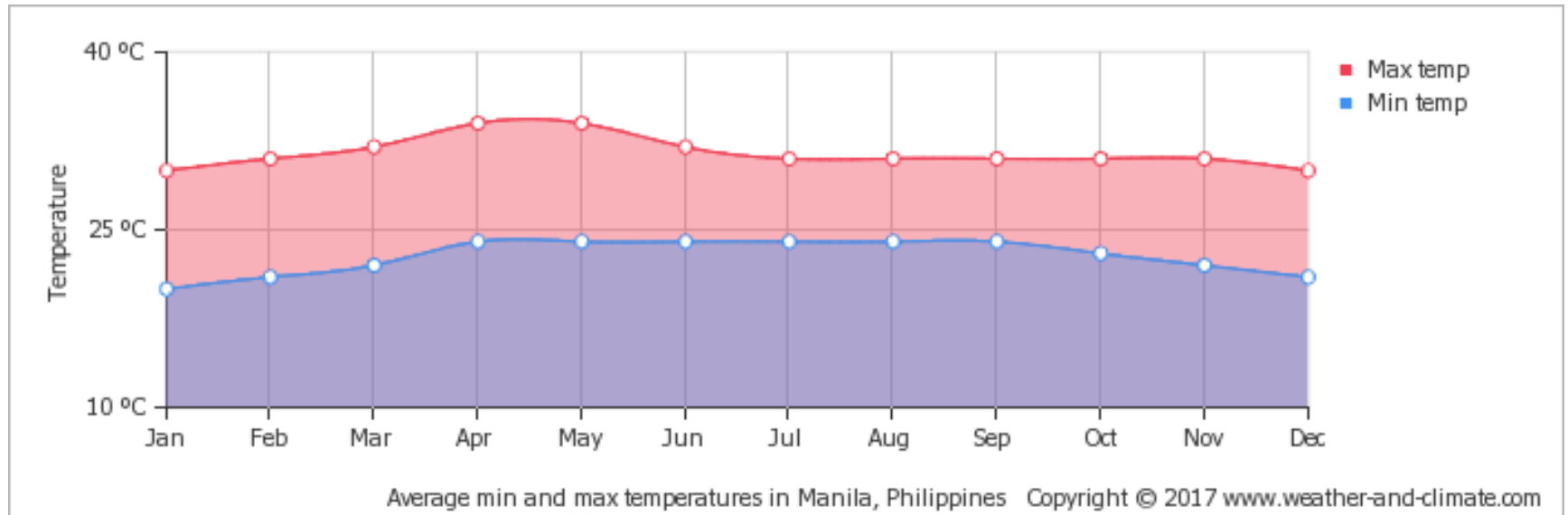
Philippines

# Applications



Philippines

# Philippines



# Applications



Spain

# Applications



Spain

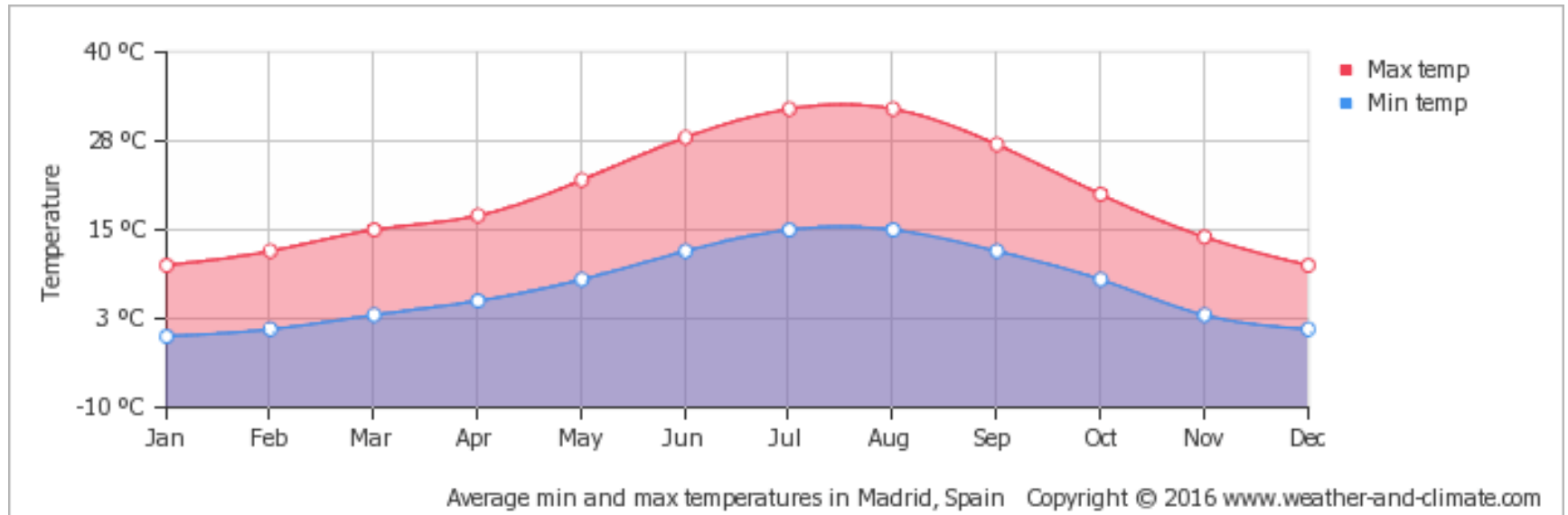
# Applications



Spain



# Spain

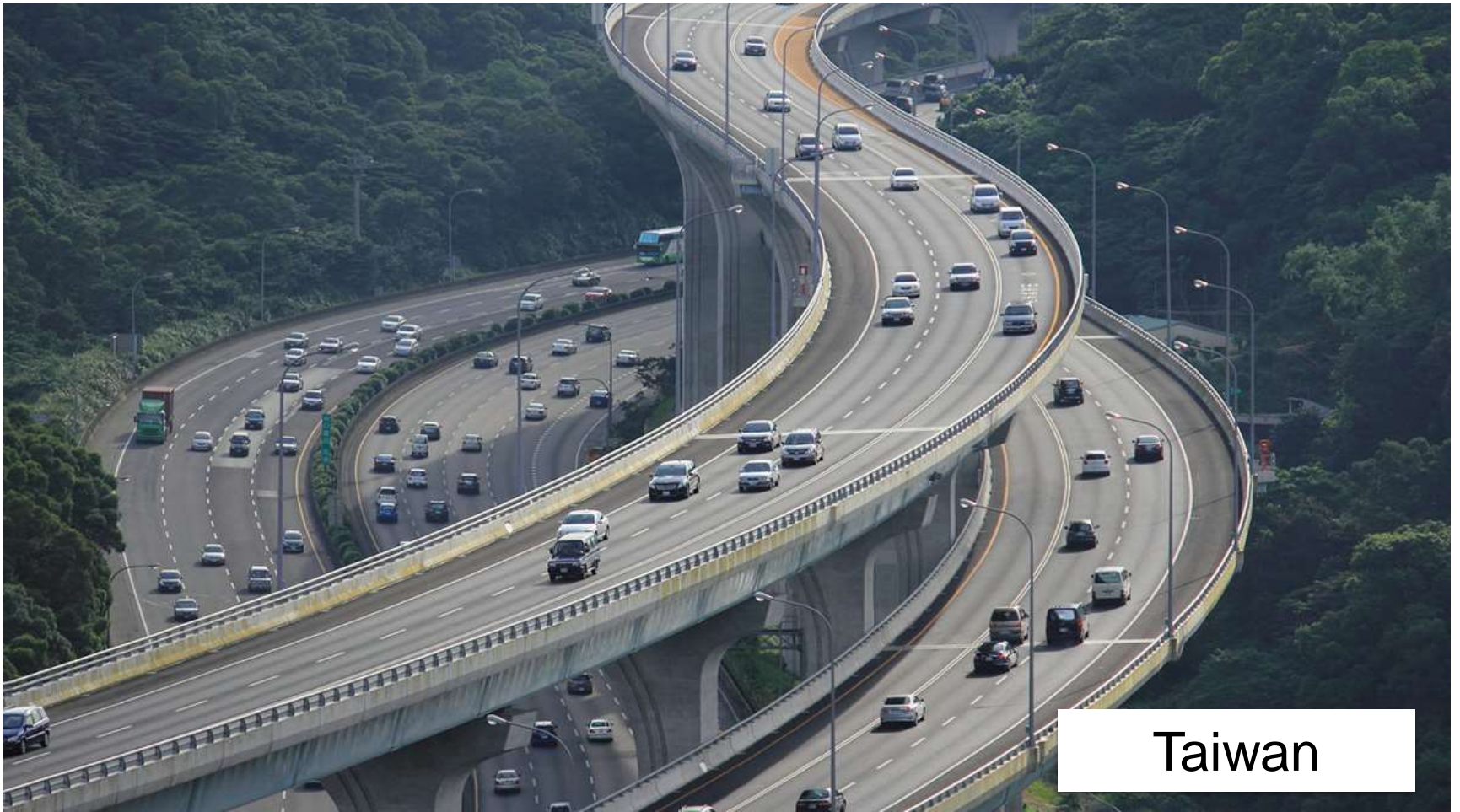


# Spain

Spain has two basic climatic areas:

- The coasts (both Mediterranean and Atlantic): average minimum temperatures around 10 °C, and average maximum temperatures around 30-35 °C
- The inside with a mild continental climate with cold winters: average minimum temperatures around -5 °C, and average maximum temperatures around 40 °C (this is the case of Madrid)

# Applications



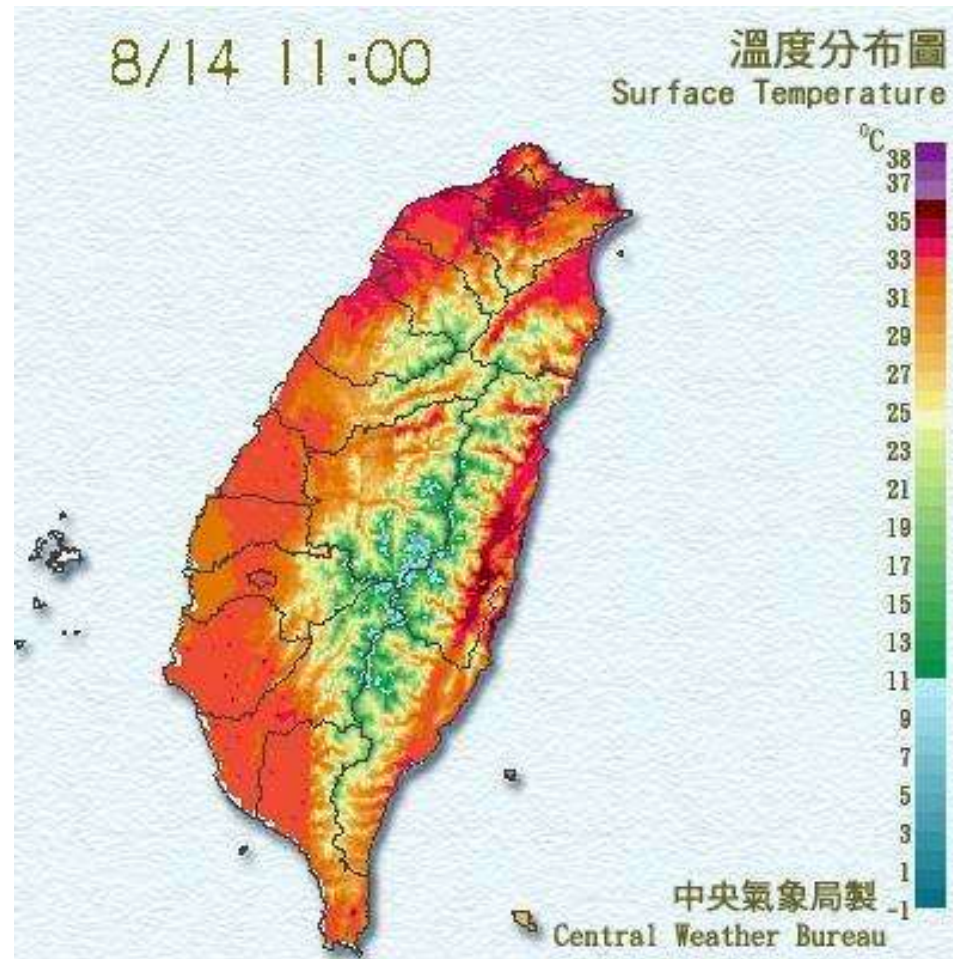
Taiwan

# Applications

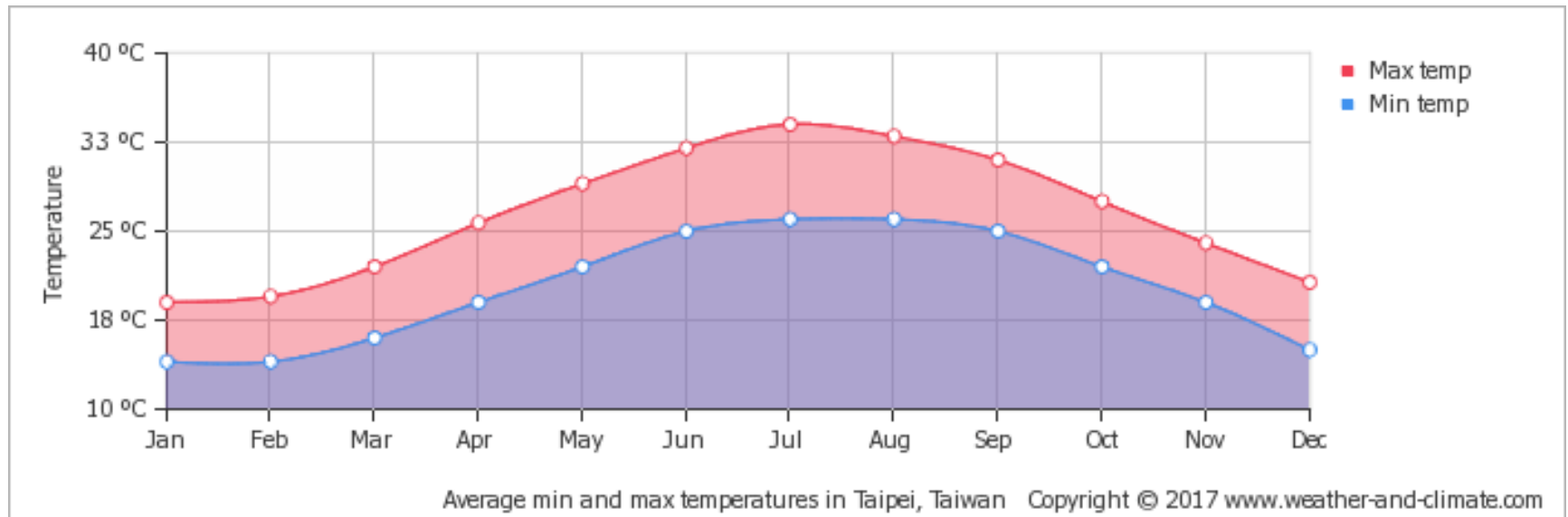


Taiwan

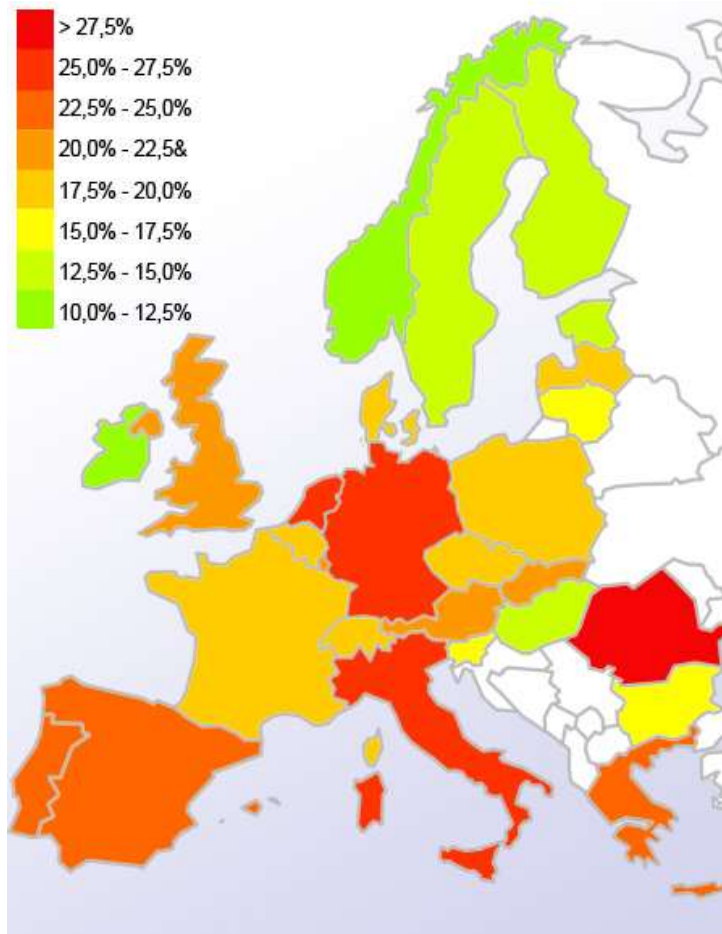
# Taiwan



# Taiwan



# Noise



**Percentage of  
population  
suffering from noise**

Source: Eurostat

# Combining PA and SMA

**PA**

**SMA plus**

**SMA**

- **Process reliable**
- **Easy to apply and to handle**
- **Simple drainage system**
- **Longer life time (x -> 20 years)**
- **Lower life-cycle costs**
- **Noise reduction**



# Noise Reducing SMA



# Requirements for SMA plus

SMA plus		SMA plus 8	SMA plus 5
Materials			
Aggregates (production size)			
Ratio crushed aggregate surface		$C_{100/0} : C_{85/1} : C_{90/1}$	$C_{100/0} : C_{95/1} : C_{90/1}$
Resistance to crushing		$SZ_{18} / LA_{20}$	$SZ_{18} / LA_{20}$
Resistance to polishing		PSV <sub>specified</sub> (51)	PSV <sub>specified</sub> (51)
Minimum part of fine aggregates 0/2 with $E_{cs}$ 35		100	100

Composition of Asphalt Mixture			
Aggregate mixture			
Passing sieve	11.2 mm	% by weight	100
Passing sieve	8 mm	% by weight	90 - 100
Passing sieve	5.6 mm	% by weight	20 - 30
Passing sieve	2 mm	% by weight	15 - 20
Passing sieve	0.063 mm	% by weight	6 - 8
			7 - 10

# Requirements for SMA plus

Binder			
Binder, type and grade		40/100-65 45/80-50 (25/55-55)	40/100-65 45/80-50 (25/55-55)
Minimum binder content <sup>1</sup> (factor $\alpha$ )	% by weight	$B_{min}$ 6.6	$B_{min}$ 7.0
Binder volume	Vol.-%	is to be specified	is to be specified
Stabilizing additive (cellulose fibers)	% by weight	$\geq 0.3$	$\geq 0.15$

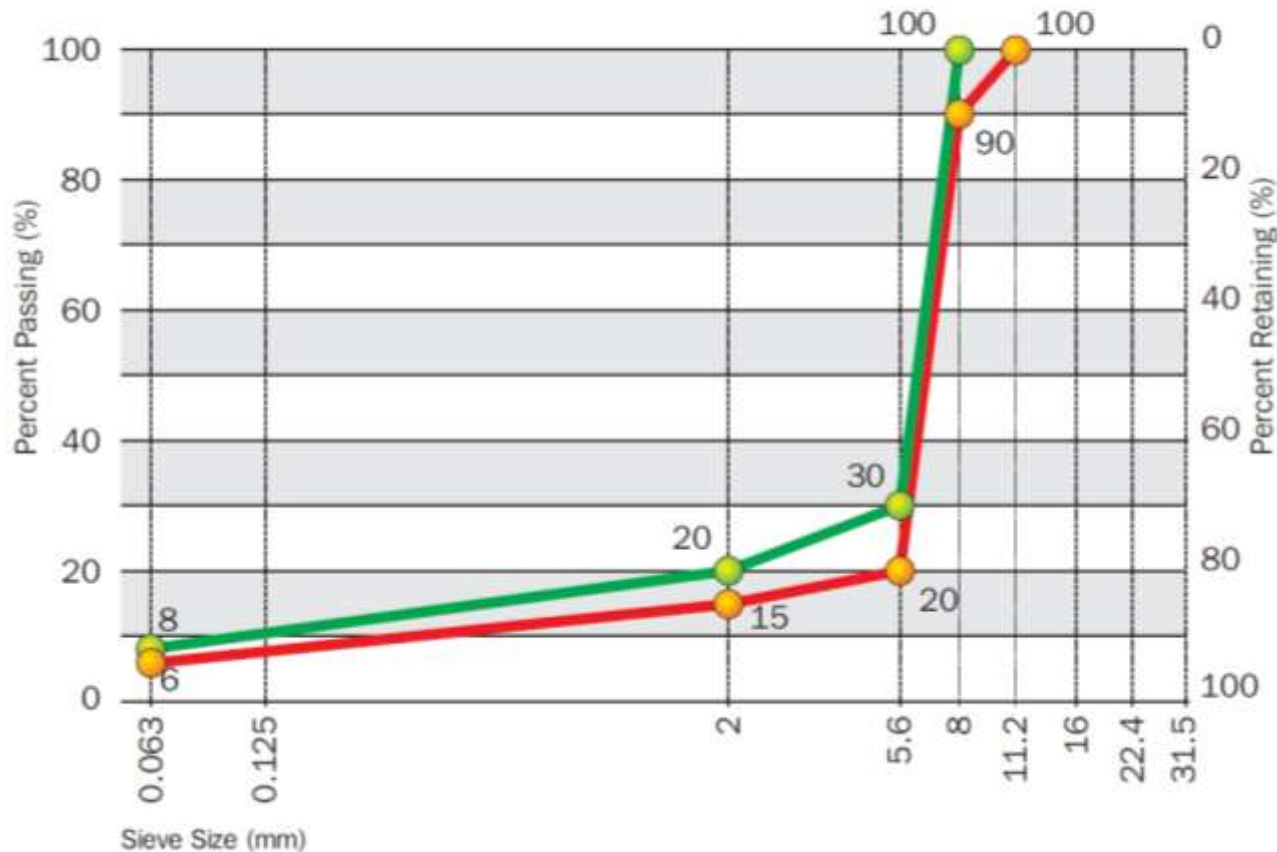
<sup>1</sup> factor  $\alpha$  considers the density of the aggregate mixture

Asphalt Mixture			
Minimum void content Marshall-Specimen	Vol.-%	$V_{min}$ 9.0	$V_{min}$ 9.0
Maximum void content Marshall-Specimen	Vol.-%	$V_{max}$ 11.0	$V_{max}$ 11.0
Voids filled with bitumen	%	is to be specified	is to be specified
Proportional rut depth	%	is to be specified	is to be specified

Characteristics of Layer			
Paving thickness	cm	2.5 - 4.0	2.0 - 3.0
Degree of compaction	%	$\geq 97.0$	$\geq 97.0$
Void content	Vol.-%	9.0 - 14.0	9.0 - 14.0
Eveness (4 m section of measurements)	mm	$\leq 3$	$\leq 3$

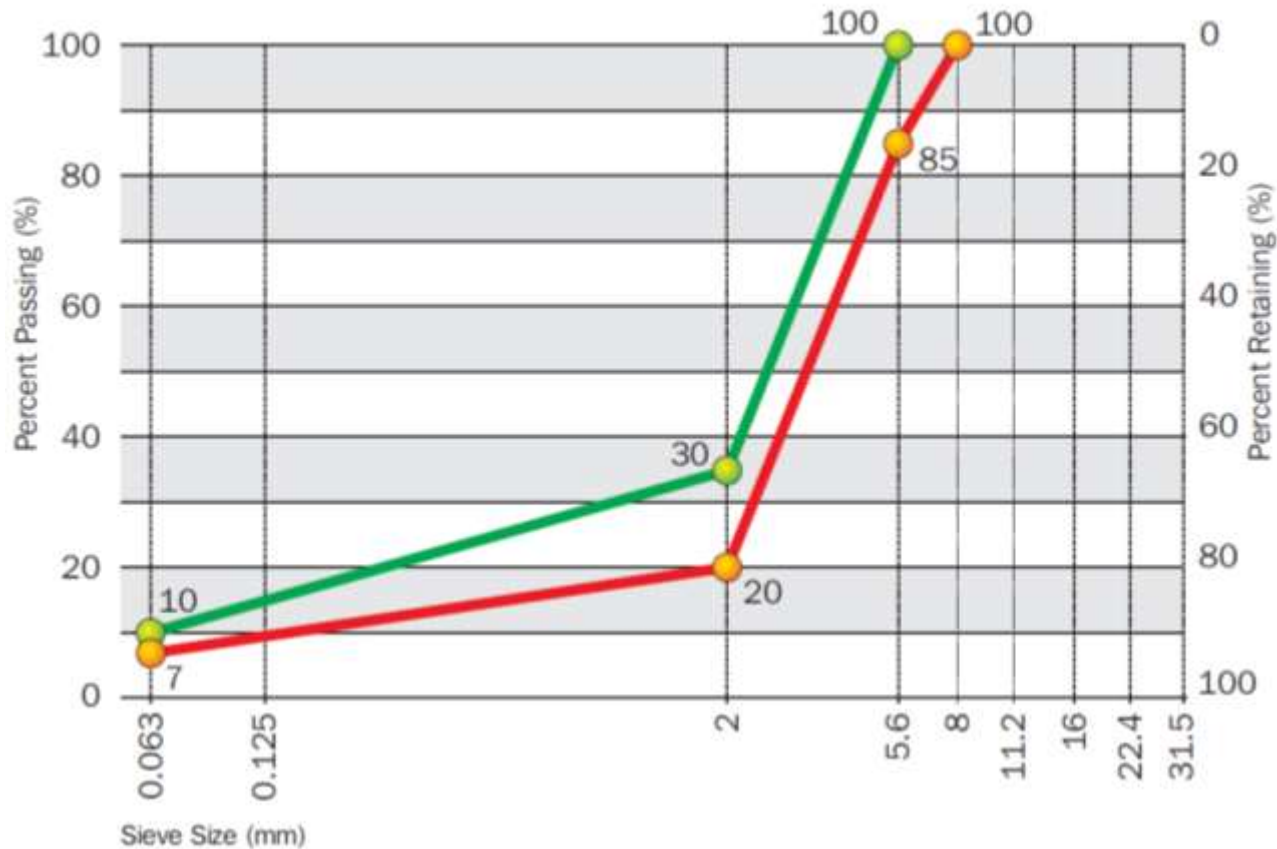
# Requirements for SMA plus

## SMA plus 8



# Requirements for SMA plus

## SMA plus 5



# Applications



# Applications



# Applications

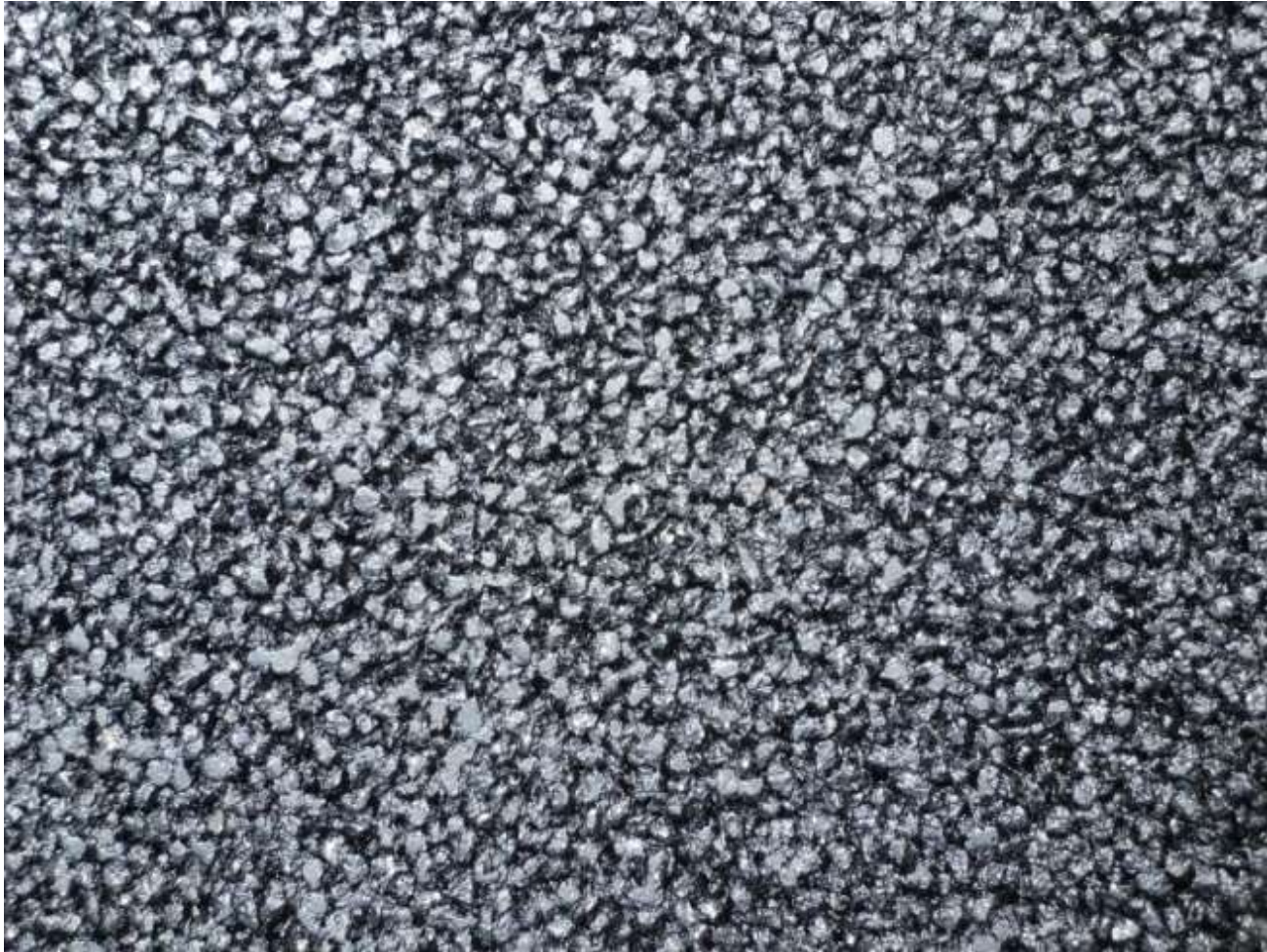




# Applications

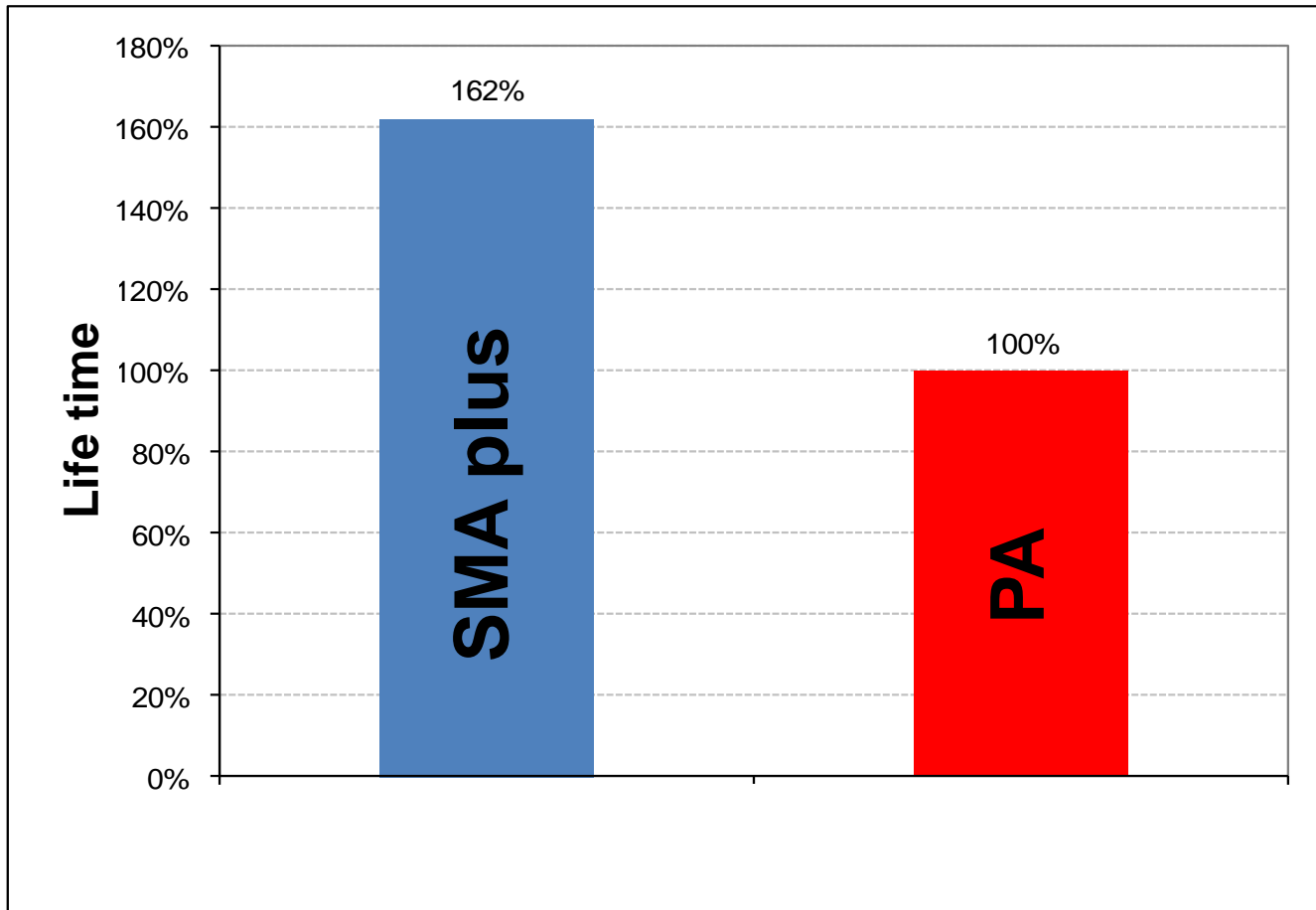


# Applications



# Noise Reducing Asphalt Pavements

	PA 8	SMA plus 8
<b>Special requirements for aggregates</b>	Yes PSV (min. 53) SI 3:1 min. 92%	No PSV (min. 51) SI 3:1 min. 80%
<b>Binder</b>	40/100-65 A	40/100-65 A
<b>Bindercontent</b>	≥ 6.5%	≥ 6.6%
<b>Fibers</b>	≥ 0.5 % by weight	≥ 0.3 % by weight
<b>Evenness binder course</b>	≤ 3 mm	≤ 4 mm
<b>Binder course</b>	AC 22 B S, AC 16 B S AC 16 B S - Typ SMA	AC 16 B S SMA 16 B C
<b>Tack coat</b>	2,000 g/m <sup>2</sup>	350 – 500 g/m <sup>2</sup>
<b>Layer thickness</b>	4.5 – 5.5 cm	2.5 – 3.5 cm
<b>Initial costs incl. tack coat</b>	€ 15.00 / m <sup>2</sup>	€ 6.50 / m <sup>2</sup>
<b>Life time</b>	8 – 10 years	14 – 16 years



# Applications



# Applications



# Applications



# Applications





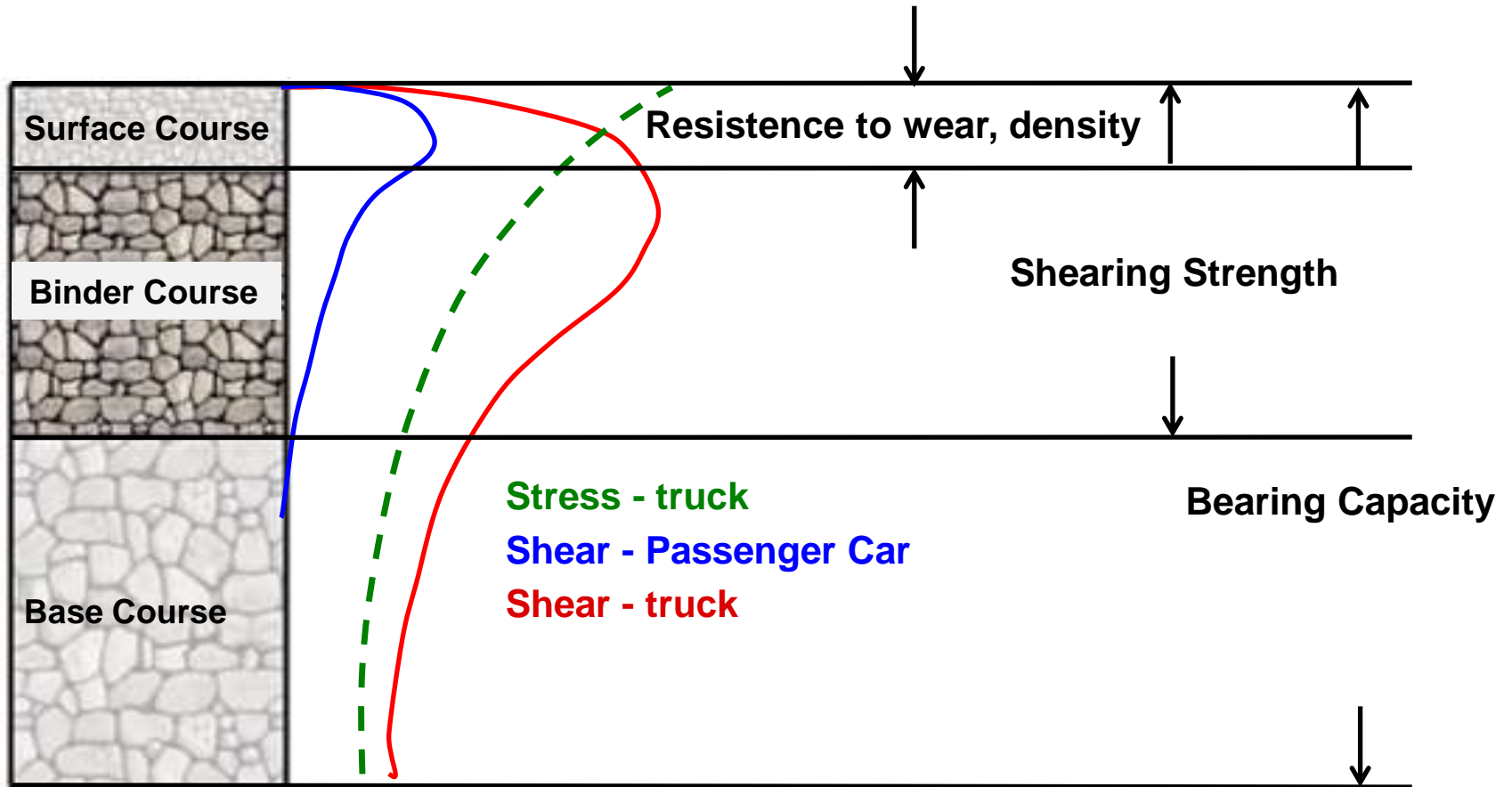
# SMA Binder Course



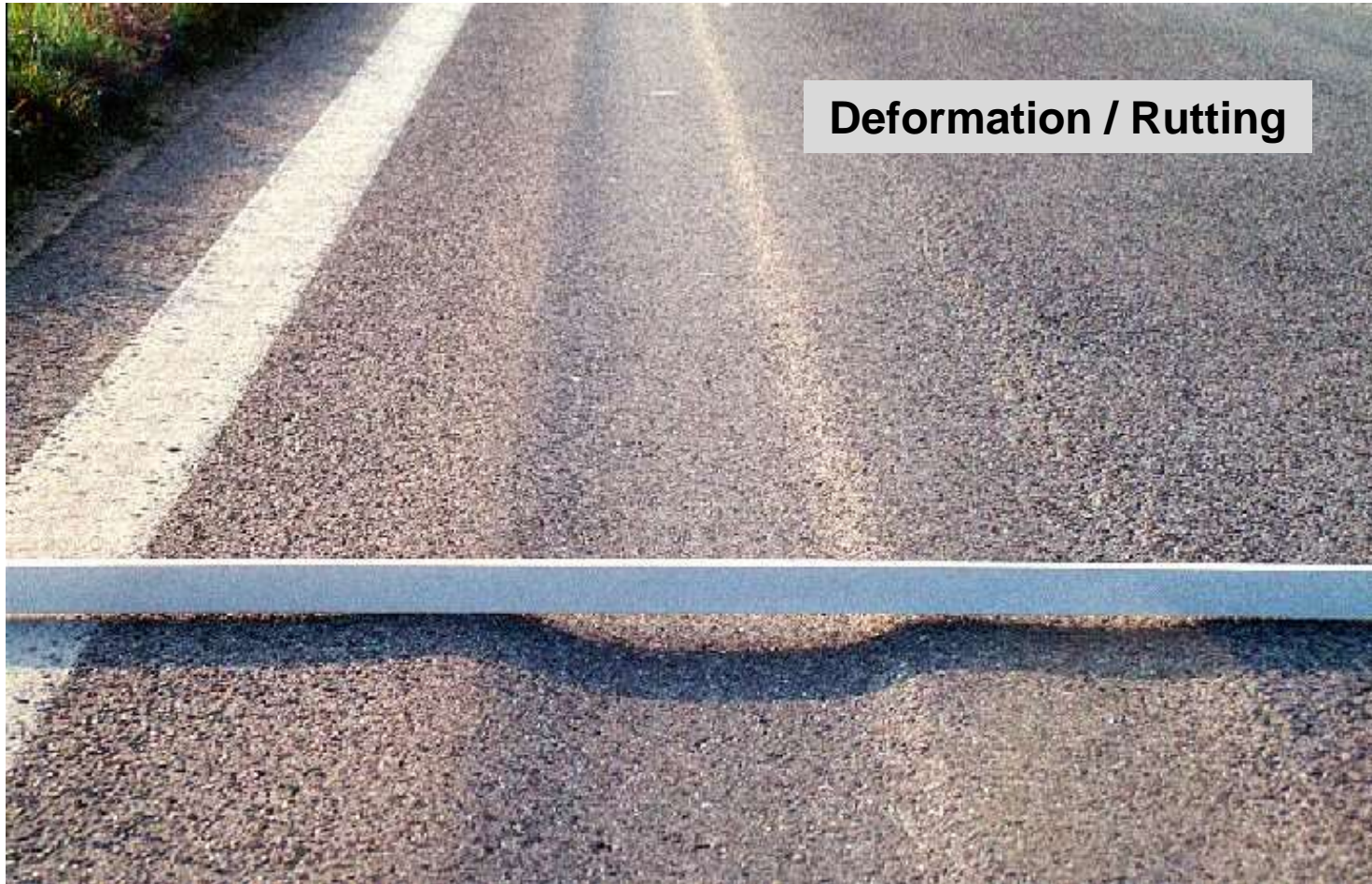
# Current Situation in Germany



# Distribution Of Loads



# Disadvantages



Deformation / Rutting

# Disadvantages



# Disadvantages



Blistering

# Disadvantages



Cracking

# Requirements for SMA B C

SMA B C		SMA 22 B C	SMA 16 B C
<b>Materials</b>			
Aggregates (production size)			
Ratio crushed aggregate surface		$C_{100/0} ; C_{95/1} ; C_{90/1}$	$C_{100/0} ; C_{95/1} ; C_{90/1}$
Resistance to crushing		$SZ_{18} / LA_{20}$	$SZ_{18} / LA_{20}$
Minimum part of fine aggregates 0/2 with $E_{CS} 35$	%	100	100

Composition of Asphalt Mixture				
<b>Aggregate mixture</b>				
Passing sieve	31.5 mm	% by weight	100	
Passing sieve	22.4 mm	% by weight	90 - 100	100
Passing sieve	16 mm	% by weight	65 - 75	90 - 100
Passing sieve	11.2 mm	% by weight	50 - 60	63 - 73
Passing sieve	8 mm	% by weight	-	46 - 56
Passing sieve	2 mm	% by weight	23 - 28	25 - 30
Passing sieve	0.063 mm	% by weight	6 - 10	6 - 10



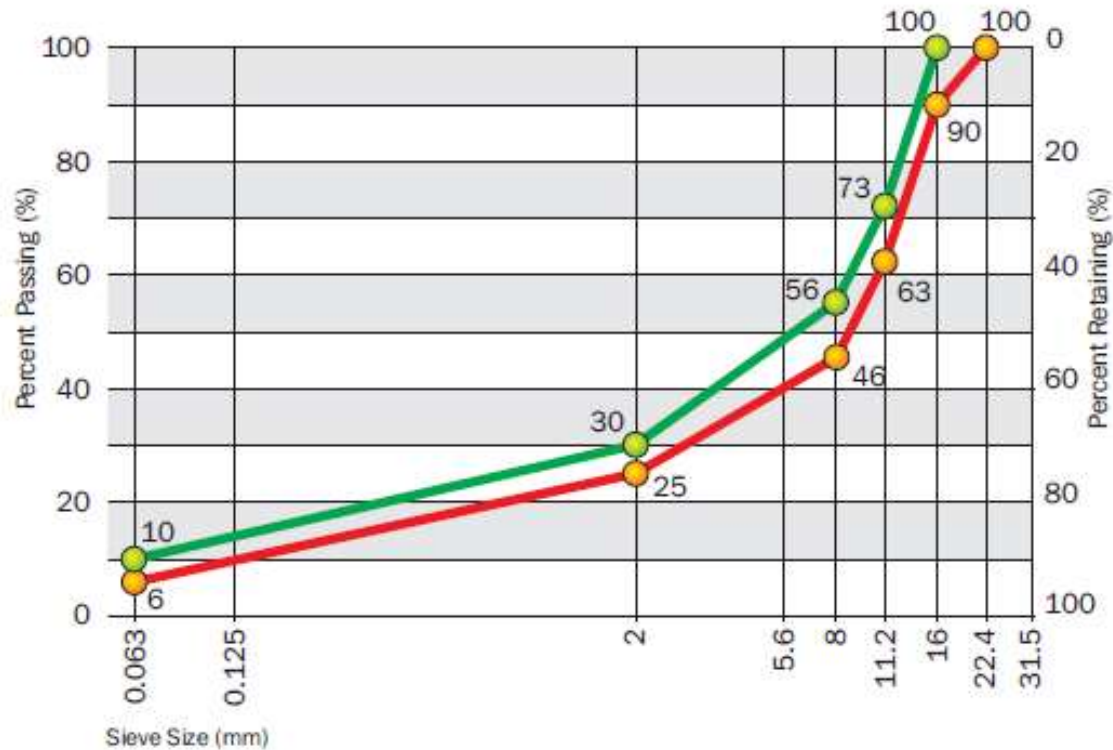
# Requirements for SMA B C

SMA B C		SMA 22 B C	SMA 16 B C
<b>Asphalt Mixture</b>			
Minimum void content Marshall-Specimen	Vol.-%	$V_{min} 3.0$	$V_{min} 3.0$
Maximum void content Marshall-Specimen	Vol.-%	$V_{max} 4.0$	$V_{max} 4.0$
Binder volume	Vol.-%	is to be specified	is to be specified
Voids filled with bitumen	%	is to be specified	is to be specified
Proportional rut depth	%	$PRD_{Av} 5.0$	$PRD_{Av} 5.0$

( ... ) in exceptions

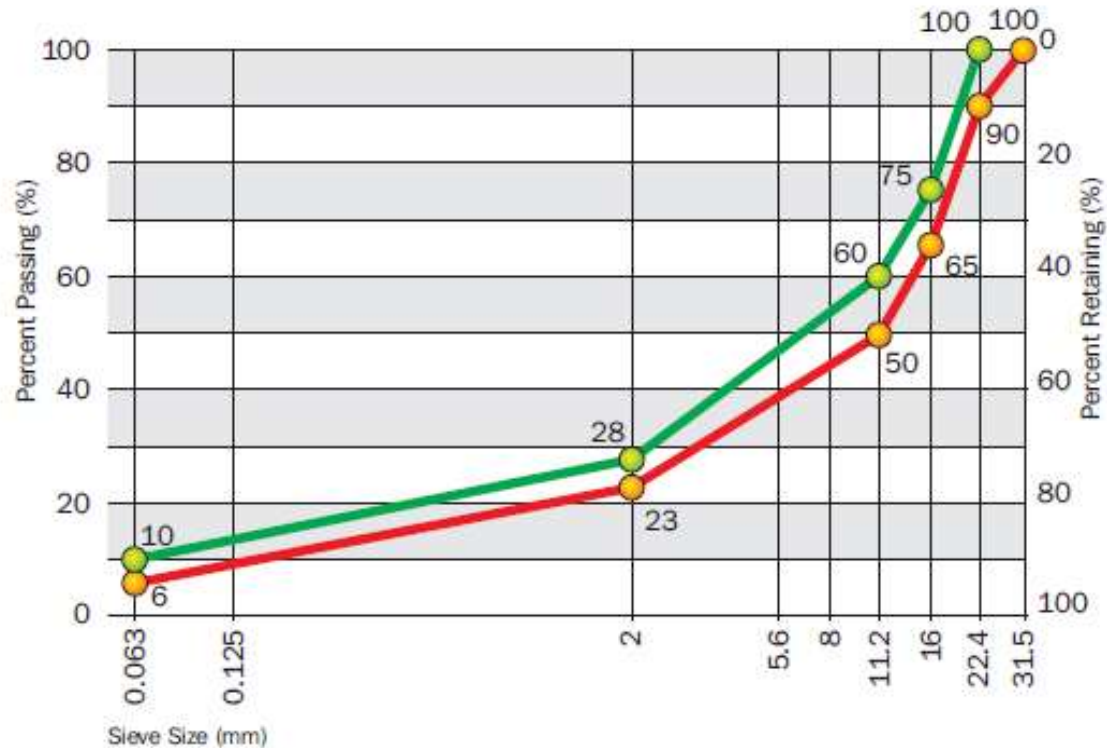
# Requirements for SMA B C

## SMA 16 B C



# Requirements for SMA B C

## SMA 22 B C



# Characteristics of Layer Asphalt Binder Courses SMA B C

SMA B C		SMA 22 B C	SMA 16 B C
<b>Characteristics of Layer</b>			
Paving thickness	cm	9.5 - 12.0	6.0 - 9.5
Degree of compaction	%	≥ 98.0	≥ 98.0
Void content	Vol.-%	1.5 - 5.5	1.5 - 5.5

# Applications



# Applications



# Applications



# Applications





# Applications



A dramatic sunset with a red and orange sky, silhouetted trees, and a building with a window.

SMA

Do it right  
or just don't do it!