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Mixing and Compaction Properties of Asphalt Mixture Modified with Silane

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Outline

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- Summary and Conclusions

Introduction

Asphalt mixture for road pavement is conventionally compacted at temperatures between T=135-160°C

A decrease in compaction temperature would:

- make the construction process **less** dependent on weather and season conditions;
- **Increase** the time window for compaction with potential benefits in terms of higher density and lower air voids content;
- A **lower** energy demand associated to lower natural resources exploitation.

Introduction

- Reduction in temperature can be achieved through additives such as wax and Zeolites;
- German experience: not always satisfactory.

Alternative: organic silane as enhancing bonding agent (used in semiconductor industry).

Objective: experimentally investigate the effect of organic silane on mixing and compaction temperature of asphalt mixture.

Material and Preparation

Asphalt Mixtures Mix Design

Type of asphalt mixture	AC 16 BS	AC 11 DS
Asphalt binder	50/70	25/55-55 A
Binder content*	4,3%	6,0%
Silane content * as function of binder content	0,10%	0,15%
Aggregates*	Gabbro	Gabbro
> 16,0 mm	2,8%	-
11,2 - 16,0 mm	28,5%	0,5%
8,0 - 11,2 mm	12,1%	20,2%
5,6 - 8,0 mm	12,8%	10,8%
2,0 - 5,6 mm	15,2%	23,3%
0,063 - 2,0 mm	22,0%	37,6%
< 0,063 mm	6,6%	7,6%

*** % percentage with respect to the total material mass**

Material and Preparation

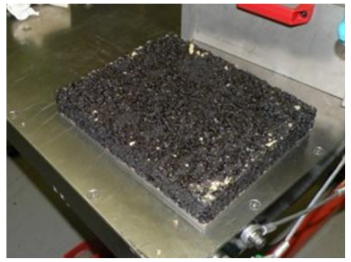
Silane addition and compaction

- The addition of silane was carried out suing a special mixer with a Cowles agitator;
- Silane was mixed together with the asphalt binder and heated up to 160°C for 10 minutes;
- The newly obtained asphalt binder was then added to the pre-heated aggregates in the mixer and the mixing process performed.

Material and Preparation

Compaction at different temperatures

ID	Asphalt Mixture	Binder	Silane	Compaction Temp.
1a	AC 16 BS	50/70	no	135 °C
1b			yes	135 °C
1c			yes	115 °C
1d			yes	95 °C
2a	AC 11 DS	25/55-55 A	no	145 °C
2b			yes	145 °C
2c			yes	125 °C
2d			yes	105 °C



Experimentation and Results

Aggregate coating

Mixing was filmed and the coating percentage of aggregate was visually estimated: 50%, 75%, 90% and 100%.

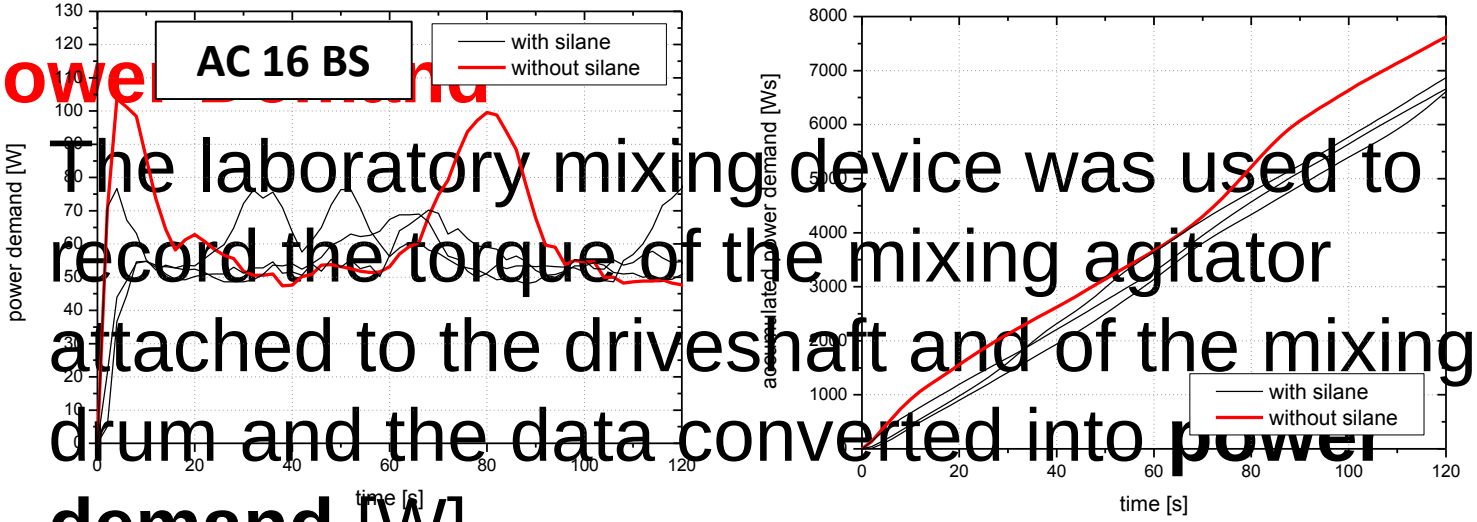
Degree of Coating	Mixture AC 16 BS				Mixture AC 11 DS			
	1a	1b	1c	1d	2a	2b	2c	2d
50 %	25s	15s	19s	19s	37s	22s	30s	30s
75 %	35s	22s	30s	29s	45s	29s	38s	39s
90 %	50s	32s	40s	43s	55s	42s	44s	46s
100 %	67s	47s	50s	55s	80s	56s	66s	61s

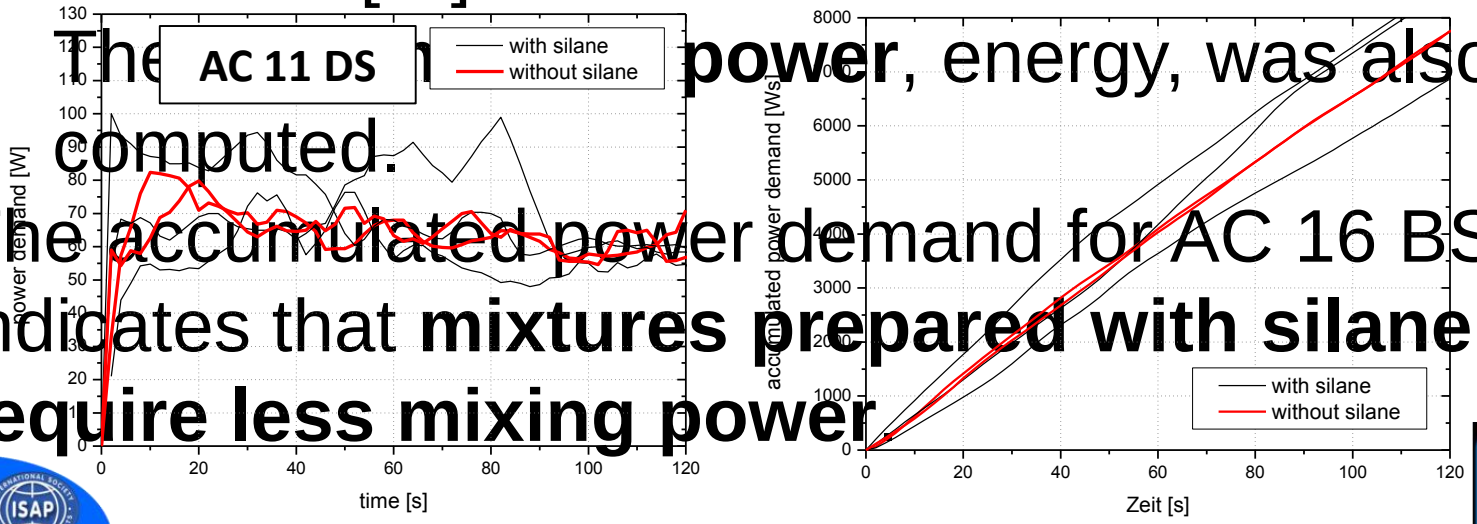
Asphalt mixture without silane (ID 1a and 2a) require a longer mixing period for coating the aggregates compared to those containing the binding agent (ID 1b, 1c, 1d and 2b, 2c, 2d)

Experimentation and Results

Power Demand

- The laboratory mixing device was used to record the torque of the mixing agitator attached to the driveshaft and of the mixing drum and the data converted into **power demand** [W].
- The **accumulated power**, energy, was also computed.





The accumulated power demand for AC 16 BS indicates that **mixtures prepared with silane require less mixing power**.

Experimentation and Results

Compactability *T*

- The compactability *T* was determined on the basis of the change in thickness of the Marshall sample during compaction.
- An exponential function can be determined whose parameter *T* provides an estimation of the material compactibility.
- Small values of *T* are typical of materials easy to compact.

Experimentation and Results

Compactability *T*

ID	Mixture	Binder	Silane	Compaction Temp.	Compactability
1a	AC 16 BS	50/70	no	135 °C	41,6Nm
1b			yes	135 °C	43,5 Nm
1c			yes	115 °C	42,8 Nm
1d			yes	95 °C	41,3 Nm
2a	AC 11 DS	25/55-55 A	no	145 °C	37,3 Nm
2b			yes	145 °C	34,2 Nm
2c			yes	125 °C	36,5 Nm
2d			yes	105 °C	36,5 Nm

Despite different compaction temperatures and silane , the compactibility, *T*, shows no significant differences.

Experimentation and Results

Density and air voids content

Asphalt mixture	AC 16 BS				AC 11 DS			
ID	1a	1b	1c	1d	2a	2b	2c	2d
Compaction Temperature °C	135	135	115	95	145	145	125	105
Bulk Density g/cm³	2,511	2,508	2,506	2,513	2,508	2,500	2,491	2,483
Max. Density g/cm³	2,684	2,711	2,713	2,688	2,618	2,615	2,627	2,622
Air Voids Content Vol.%	6,4	7,5	7,6	6,5	4,2	4,4	5,2	5,3
Mean Max. Density g/cm³	2,699				2,621			
Mean Air Voids Content Vol.%	7,0	7,1	7,2	6,9	4,3	4,6	5,0	5,3

- Similar maximum density with or without silane additive.
- Tendency of increasing air voids contents for decreasing compaction temperatures.

Summary and Conclusions

Summary

- The influence of the silane binding agent on the mixing process and to compaction properties of asphalt mixture was investigated.
- Two types of asphalt mixtures, one for wearing course and one for binder course, were prepared.
- Mixing power consumption, times to different degrees of coating, compactability and air voids content were measured.

Summary and Conclusions

Conclusions

- Coating requires 20 % less time when using silane.
- Less power consumption was observed for binder layer mixture when adding silane.
- The compactibility does not show any difference with and without binding agent.
- The maximum density of the asphalt mixtures produced can be considered equivalent.
- The bulk density of the roller compacted slabs show minimal differences

Thank you

Vielen Dank

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