

# AV'15

KONFERENCE  
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## Effects of a chemically reactive silane additive on binder-aggregate interaction

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## Task of project

**ZycoTherm® - adhesion agent based on nanotechnology and chemically reactive silane additives laboratory testing for evaluation of its effectiveness with regard to**

- ➔ adhesion**
- ➔ mixing**
- ➔ coating**
- ➔ compaction**

## **Blending of bitumen and ZycoTherm®**

**ZycoTherm® was mixed together with bitumen heated up to 160°C for at least 10 minutes**

**The bitumen-ZycoTherm®-mixture was added to pre-heated stone in the mixer and then the mixing process was started**

## Blending of bitumen and ZycoTherm®



Blending of bitumen and ZycoTherm®:  
cowles agitator (left) and mixer used (right)

## Testing adhesion

**Rolling Bottle Test acc. EN 12697-11 A**

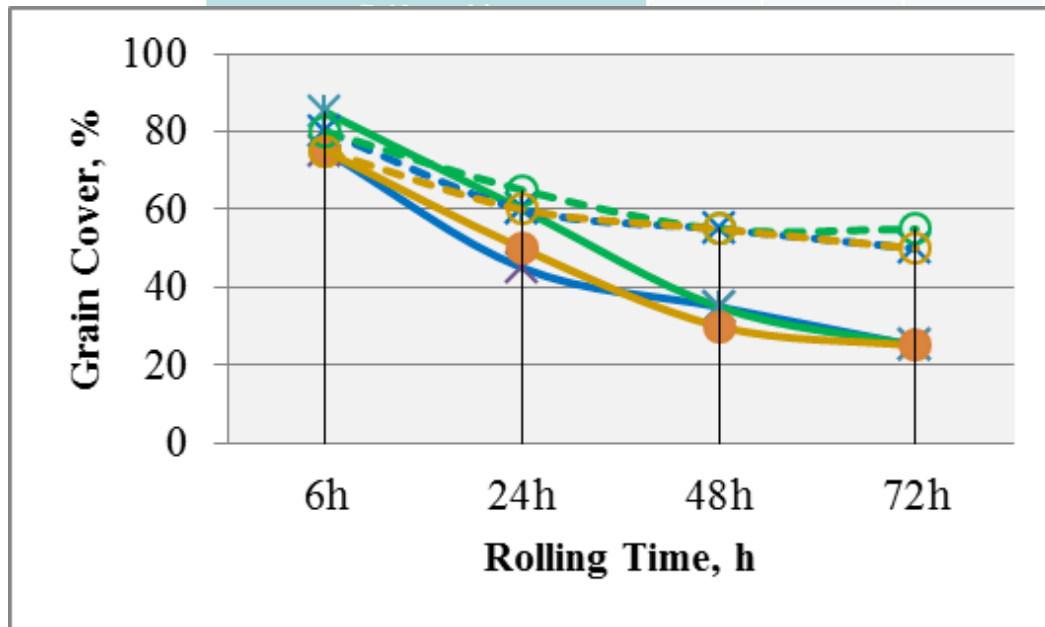
**2 bitumen: 50/70 and PmB 45/80-65 (with and without  
0,15% ZycoTherm®)**

**4 aggregates: Greywacke, Limestone, Granite, Basalt**

**2 operators**

# Adhesion test results

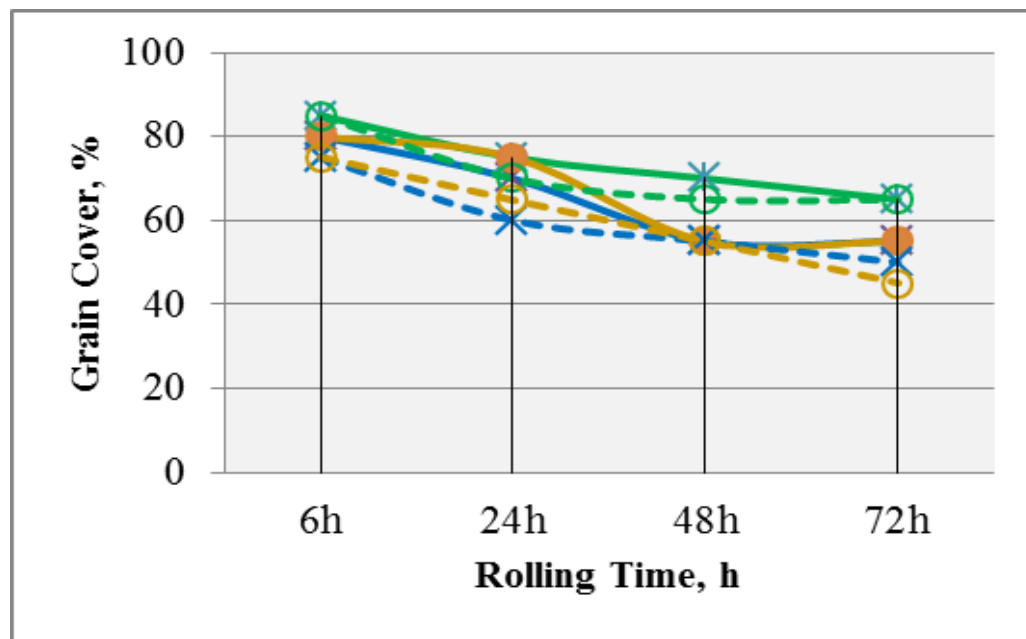
GREYWACKE 8/11	Plain				+0,15% ZYCOTHERM			
	6h	24h	48h	72h	6h	24h	48h	72h
GREYWACKE 8/11 (50/70 B Spain)	75	45	35	25	80	60	55	50
GREYWACKE 8/11 (45/80-65 Spain)	85	60	35	25	80	65	55	55
GREYWACKE 8/11 (50/70)	75	50	30	25	75	60	55	50



Adhesivity of binders to Greywacke without (continuous) or with (dash) ZYCOTHERM

# Adhesion test results

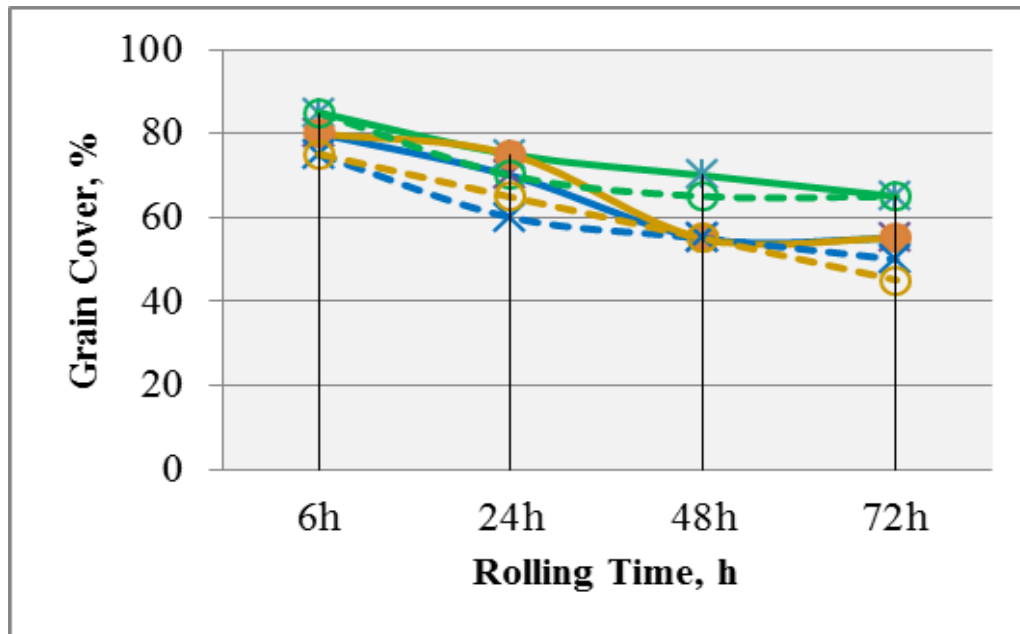
LIMESTONE 8/11	Plain				0,15% ZYCOTHERM			
	6h	24h	48h	72h	6h	24h	48h	72h
LIMESTONE 8/11 (50/70 B Spain)	80	70	55	55	75	60	55	50
LIMESTONE 8/11 (45/80-65 Spain)	85	75	70	65	85	70	65	65
LIMESTONE 8/11 (50/70 B Kuwait)	80	75	55	55	75	65	55	45



**Adhesivity of binders to Limestone without (continuous) or with (dash) ZYCOTHERM**

# Adhesion test results

LIMESTONE 8/11	Plain				0,15% ZYCOTHERM			
	6h	24h	48h	72h	6h	24h	48h	72h
LIMESTONE 8/11 (50/70 B Spain)	80	70	55	55	75	60	55	50
LIMESTONE 8/11 (45/80-65 Spain)	85	75	70	65	85	70	65	65
LIMESTONE 8/11 (50/70 B Kuwait)	80	75	55	55	75	65	55	45

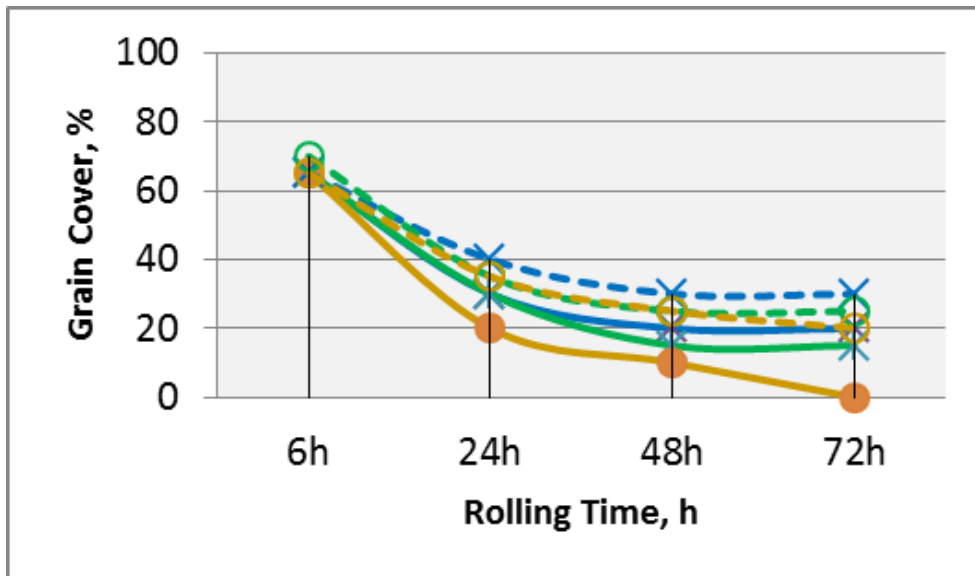


Adhesivity of binders to Limestone without (continuous) or with (dash) ZYCOTHERM



# Adhesion test results

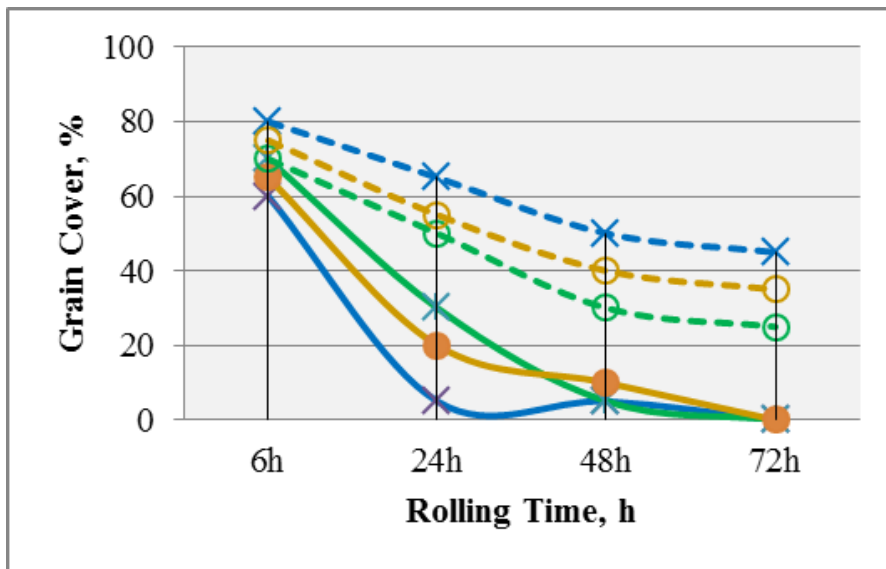
BASALT 8/11	Plain				0,15% ZYCOTHERM			
	6h	24h	48h	72h	6h	24h	48h	72h
BASALT 8/11 (50/70 B Spain)	65	30	20	20	65	40	30	30
BASALT 8/11 (45/80-65 Spain)	65	30	15	15	70	35	25	25
BASALT 8/11 (50/70 B Kuwait)	65	20	10	0	65	35	25	20



**Adhesivity of binders to Limestone without (continuous) or with (dash) ZYCOTHERM**

# Adhesion test results

GRANITE 8/11	Plain				0,15% ZYCOTHERM			
	6h	24h	48h	72h	6h	24h	48h	72h
GRANIT 8/11 (50/70 B Spain)	60	5	5	0	80	65	50	45
GRANIT 8/11 (45/80-65 Spain)	70	30	5	0	70	50	30	25
GRANIT 8/11 (50/70 B Kuwait)	65	20	10	0	75	55	40	35



**Adhesivity of binders to Granite without (continuous) or with (dash) ZYCOTHERM**

## Testing mixing performance

Drum mixer

Asphalt mixture variants with ZycoTherm® and reference mixtures without

2 types of asphalt concrete mixtures produced

- ➔ AC 16 B S for binder course, plain bitumen 50/70
- ➔ AC 11 DS for wearing course, polymer modified bitumen 25/55-55

## Asphalt mixture variants

Asphalt mixture		AC 16 B S	AC 11 D S
Bitumen		50/70	25/55-55 A
Bitumen content	M. %	4,3	6,0
ZycoTherm content in Bitumen	M. %	0,10	0,15
Aggregate		Gabbro	Gabbro
> 16,0 mm	M. %	2,8	-
11,2 – 16,0 mm	M. %	18,5	0,5
8,0 – 12,0 mm	M. %	12,1	20,5
5,6 – 8,0 mm	M. %	12,8	10,8
2,0 – 5,6 mm	M. %	15,2	23,3
0,063 – 2,0 mm	M. %	22,0	37,5
< 0,063 mm	M. %	6,6	7,6

## Testing mixing performance

**Power demand:** During the mixing process the laboratory mixing device recorded the torque of the agitator and the mixing drum, and from these parameters the needed power demand was calculated (W).

**Accumulated power demand:** Performance energy was plotted over time for a two minute mixing duration, and accumulated power demand (Ws) was represented.

## Testing coating performance

During the 2 minute mixing process, all 8 asphalt variants were filmed and then the time for a specified degrees of coating of the stones was estimated.

### Degrees of coating

- ➔ 50%
- ➔ 75%
- ➔ 90%
- ➔ 100%

# Coating results

times for different degrees of coating

variant		AC 16 B S (50/70)				AC 11 D S (25/55-55 A)			
		1a	1b	1c	1d	2a	2b	2c	2d
compctn. temp. [°C]		135	135	115	95	145	145	125	105
coating [%]	50	25 s	15 s	19 s	19 s	37 s	22 s	30 s	30 s
	75	35 s	22 s	30 s	29 s	45 s	29 s	38 s	39 s
	90	50 s	32 s	40 s	43 s	55 s	42 s	44 s	46 s
	100	67 s	47 s	50 s	55 s	80 s	56 s	66 s	61 s

## **Coating results**

**Variants without Zycotherm® require a significantly longer period for coating**  
**Similarly observed during the mixing process**



## **Testing compactibility**

**Marshall blow compaction to evaluate compactibility at various compaction temperatures**

**Compaction resistance (T) was determined from the change in thickness of the asphalt sample during compaction.**

**An exponential function for compaction resistance (T) was assessed, where small T-values are linked with easy compressibility and vice versa.**

## Asphalt mixture variants

Variant	Mixture type	Bitumen	Addition of ZycoTherm®	Compaction temperature, °C
1a	AC 16 B S	50/70	No (reference)	135
1b			Yes	135
1c			Yes	115
1d			Yes	95
2a	AC 11 D S	25/55-55 A	No (reference)	145
2b			Yes	145
2c			Yes	125
2d			Yes	105

## Compaction results

Compaction resistance T of the asphalt variants for different compaction temperatures

Asphalt mixture	Variant	Compaction temperature, °C	Compaction resistance T, 21 Nm
AC 16 B S	1a	135	41,6
	1b	135	43,5
	1c	115	42,8
	1d	95	41,3
AC 11 D S	2a	145	37,3
	2b	145	34,2
	2c	125	36,5
	2d	105	36,5

## **Validation of compaction parameters**

**roller compaction acc. to EN to validate resulting densities and void contents**

- asphalt plates 300 x 260 x 40 mm<sup>3</sup> (AC 11 D S)**
- asphalt plates 300 x 260 x 50 mm<sup>3</sup> (AC 16 B S)**

**compaction parameters fixed (load, number of rolls, etc.) for all variants, but variation of compaction temperature**

## Validation of compaction parameters

	AC 16 B S (50/70)				AC 11 D S (25/55-55 A)			
Variant	1a	1b	1c	1d	2a	2b	2c	2d
Compaction temperature, °C	135	135	115	95	145	145	125	105
Density, g/cm <sup>3</sup>	2,511	2,508	2,506	2,513	2,508	2,500	2,491	2,483
Bulk density, g/cm <sup>3</sup>	2,684	2,711	2,713	2,688	2,618	2,615	2,627	2,622
Void content, Vol. %	6,4	7,5	7,6	6,5	4,2	4,4	5,2	5,3
Average bulk density, g/cm <sup>3</sup>	2,699				2,621			
Void content, Vol. %	7,0	7,1	7,2	6,9	4,3	4,6	5,0	5,3

## Validation of compaction parameters

Var.	Mix type	ZycoTherm	Compaction Temp. [°C]	50% coating [sec]	Compaction resistance T [21 Nm]	Air void content [Vol-%]
1a	AC 16 BS, 50/70	No	135	25 s	41.6	7.0
1b		Yes	135	15 s	43.5	7.1
1c		Yes	115	19 s	42.8	7.2
1d		Yes	95	19 s	41.3	6.9
2a	AC 11 DS, 25/55-55A	No	145	37 s	37.3	4.3
2b		Yes	145	22 s	34.2	4.6
2c		Yes	125	30 s	36.5	5.0
2d		Yes	105	30 s	36.5	5.3

## Conclusions

**ZycoTherm® is an organosilicon compound new generation antistripping agent used for asphalt mixtures. It is mixed to bitumen in an amount of 0,05% to 0,2% by bitumen weight.**

**Coating requires, on average, 20 % less time when using ZycoTherm®.**

**Compactibility does not show any difference for both asphalt mixture types, AC 16 B S (50/70) and AC 11 D S (25/55-55A), with and without binding agent.**

**Less power consumption was observed for binder layer mixture when adding ZycoTherm® to the mix design.**

**The maximum density of the asphalt mixtures produced can be considered equivalent, while the bulk densities of the roller compacted mixture slabs indicate minimal differences.**

## **Conclusions**

**An effect of compaction temperature on air voids content was observed only for the wearing course mixture with increasing values for lower compaction temperatures**

**When including ZycoTherm® in the mix design aggregate, coating time is reduced as well as compaction temperature**



**Thank you for your  
attention**

