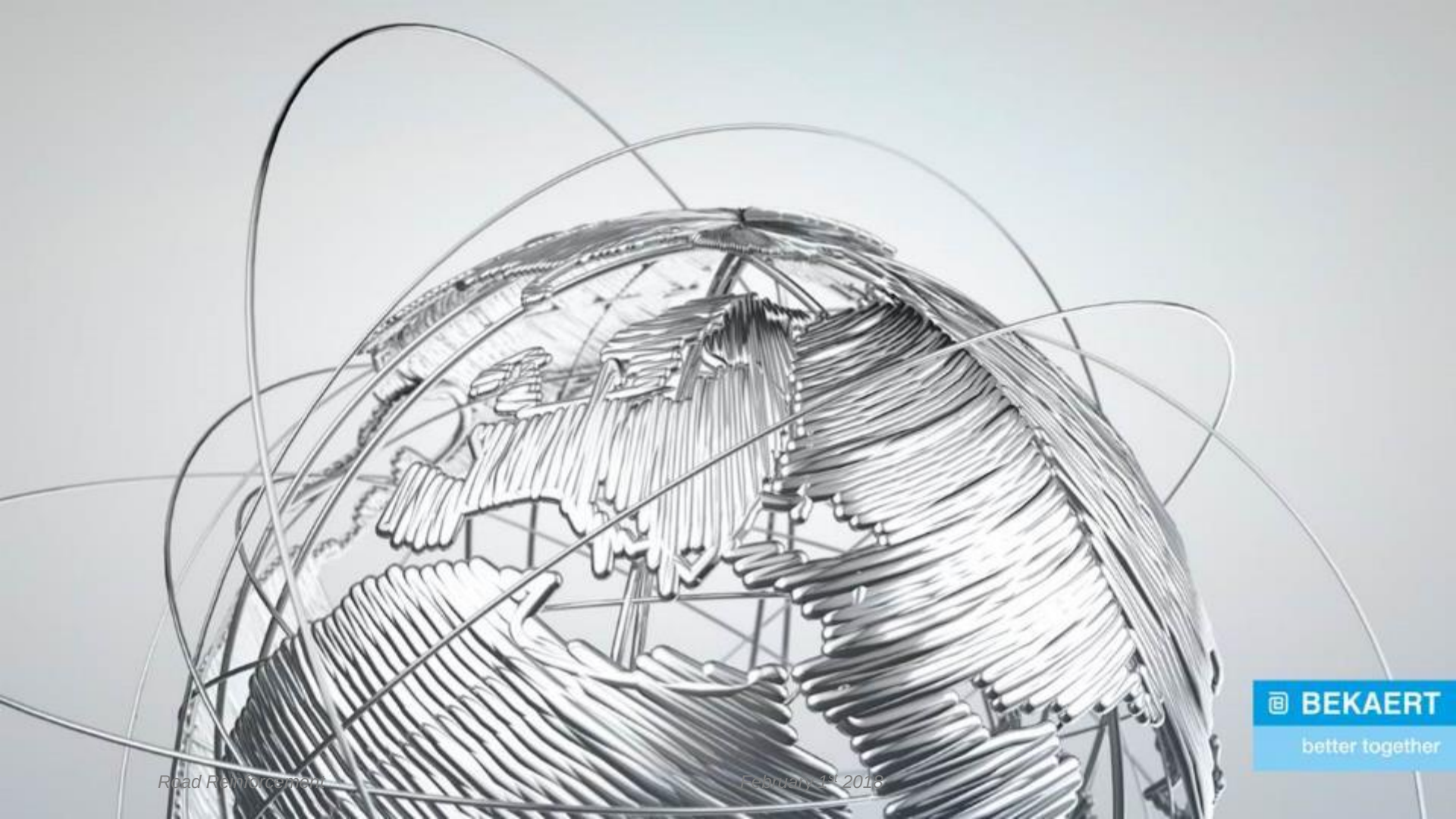


BEKAERT
better together

Performance testing anti-cracking interlayers

Frederik Vervaecke

Zwevegem

February 2018

Confidentiality

This document remains the exclusive property of NV Bekaert SA.

Communication thereof is wholly confidential and does not extend beyond the technical staff of the addressee, who is not authorized to duplicate this document nor to make known to a third party any contents thereof.

NV Bekaert SA is exclusively entitled to apply for a patent for any patentable element contained in this document.

NV Bekaert SA disclaims all liability which may arise out of the putting into use of the information contained in this document, provided it did not assume control thereof. It also disclaims all liability for infringements of industrial property rights which may arise out of the putting into use of the information contained in this document.

All the information contained in this document is based on reasonable research, but does not guarantee any result.

Standardized testing of anti-cracking interlayers for asphalt:

Properties interlayer

Tensile testing

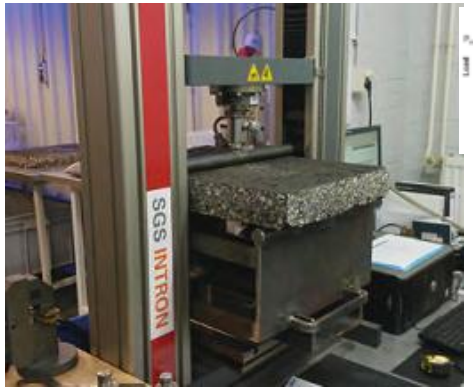
Bitumen retention test

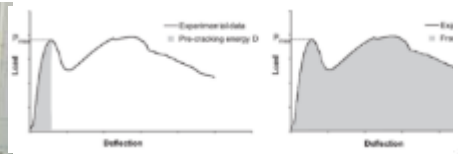
Performance anti-cracking interlayer

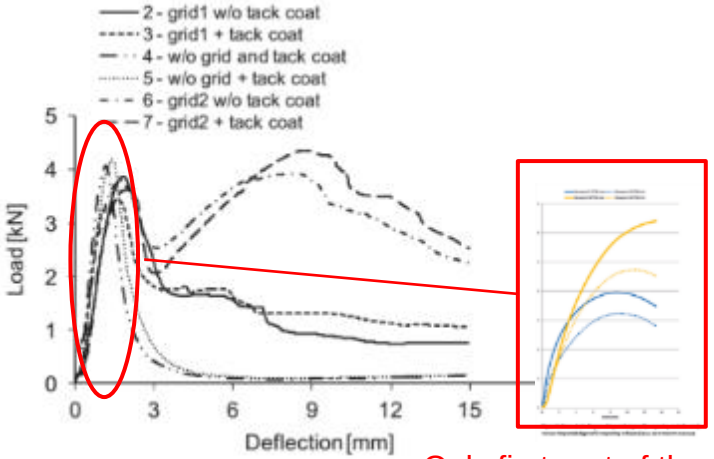
Nothing standardized

Big variaty of performance tests of anti-cracking interlayers:

1. Static testing : 3- or 4-pt bending test:







Pro:
- fast test;
- Simple setup;
- Relative large samples;

Contra:
- Relavant for reality?
- Not straight forward interpretation;

Only first part of the curve was recorded & investigated

A.G. Kneepkens, M Verweij, 2015, "Gewapende feiten over asfaltwapening", Civielm techniek Nr , 30-33
E. Pasquini, M. Bocci, G. Ferrotti, & F. Canestrari, éà&", "Laboratory characterisation and field validation of geogrid-reinforced asphalt pavements", Road Mat. & Pav. Design, 14:1, 17-35.

Big variaty of performance tests of anti-cracking interlayers:

2. Cyclic bending tests:

Several setups and research groups have there own test (Nottingham, Santander, Teheran, Italy,…)

D.Z. Zamora-Barraza, MA. Calzada-Pérez, D. Castro-Fresno, A. Vega-Zamanillo, 2011, *"Evaluation of anti-reflective cracking systems using geosynthetics in the interlayer zone, Geotextiles & geomembranes 29, 130-136.*

J. Norambuena-Contreras,& I Gonzalez-Torre, 2015, "*Influence of geosynthetic type on retarding cracking in asphalt pavements",* Construction & Building Materials 78, 412-429.

I. Gonzalez-Torre, M Calzada-Perez, A. Vega-Zamanillo, D. Castro-Fresno, 2015, *"Evaluation of reflective cracking in pavements using a new procedure that combine loads with different frequencies*", Construction & Building Materials 75, 368-374.

G. Ferrotti, F. Canestrari, A. Virgili, A. Grilli, "*A strategic laboratory approach for the performance investigation of geogrids in flexible pavements*," Construction and Building Materials 25 (2011) 2343-2348

A.Virgili, F. Canestrari, A. Grilli, F.A. Santagata, "*Repeated load test on bituminous systems reinforced by geosynthetics*", Geotextiles and Geomembranes 27 (2009) 187-195

S. Fallah & A. Khodaii, 2015, *"Reinforcing ocverlay to reduce reflection cracking; an experimental* investigation", Geotextiles & Geomembranes 43, 216-227.

Brown, *"An assessment of geogrid use in railways and asphalt applications"*, Jubilee 2009.

Brown, Brunton, Hughes & Bodrick, 1985, "*Polymer grid reinforcement of asphalt",* Journal as Asphalt Technology, 54, 18-41.

Brown Thom, & Sanders, 2001, *"A study of grid reinforced asphalt to combat reflection cracking",* Journal of Asphalt Paving Technology; 70, 543-570.

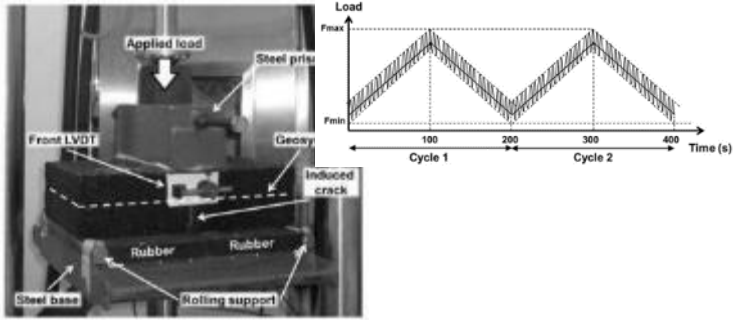
BEKAERT
better together

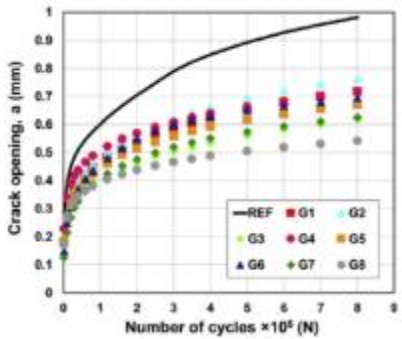
Big variaty of performance tests of anti-cracking interlayers:

2. Cyclic bending tests:

Several setups and research groups have there own test (Nottingham, Santander, Teheran, Italy,…)

Example:





Pro:

- Relative simple test setup;
- Relative large samples;

Contra:

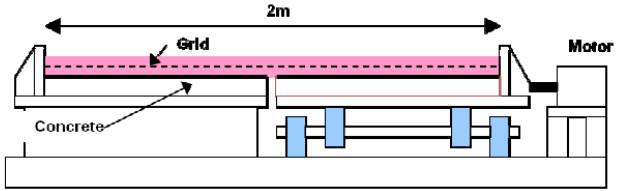
- Long test
- Spread on results (fatigue)
- Not straight forward interpretation

Big variaty of performance tests of anti-cracking interlayers:

3. Thermal movement test:

Several setups and research groups have there own test (Nottingham, Texas, Belgium, ...)

Example:



Contra:

- Long test
- Spread on results (fatigue)
- Special setup is needed

Pro:

- Realistic seasonal movement;
- Relative large samples are possible;

J. Li, J. Oh, B Naik, G.S. Simate, L.F. Walabitu, "*Laboratory characterization of cracking-resistance potential of asphalt mixes using overlay tester",* Con. & Build, mat. 70 (2014), 130-140;
L.F. Walubita, A.N.M. Faruk, J. Zhang, X. Hu, "*Charaterizing the cracking & fracture properties of geosyntehtic interlayer reinforced HMA samples using the Overlay Tester (OT)",* Con. & Build, mat. 93 (2015), 695-702;
F. Zhou, S. Hu, D. Chen, T. Scullion, "*Overlay tester: A simple performance test for fatigue cracking"*, TRB 2007 Annual Meeting
R. Lytton, "*Use of geotextiles for reinforcement and strain belief in asphalt concrete",* Geotextiles and Geomembranes 8 (1989) 217-237

Big variaty of performance tests of anti-cracking interlayers:

4. Large scale fatigue testing:

Several setups and research groups have there own test (France, Spain, Switserland,Netherlands, ...)

Example:

Contra:

- Long test
- Spread on results (fatigue)
- Special setup is needed
- Complete road structure not only the asphalt/interlayer composite
- Very expensive

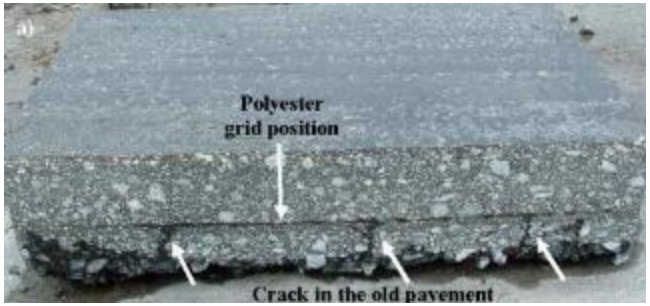
Pro:

- Realistic situation
- Entire road structure

https://www.hbm.com/en/5949/cedex-test-track-accelerated-pavement-testing/

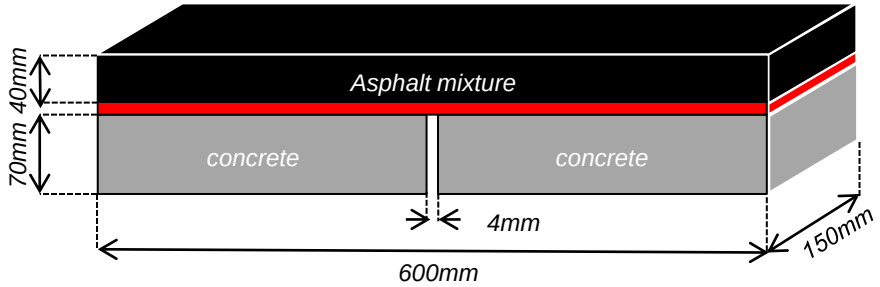
Important parameters for testing anti-cracking interlayers:

- *Testing the composite (interlayer, tack coat & asphalt) as it is used in the application;*
- *As reflective cracking is a fatigue behavior, it is important to perform cyclic testing;*



- *Sample dimensions must be adapted to the dimensions of the anti-cracking interlayer;*
- *Details of asphalt, tack coat, base layer need to be kept unchanged;*

Thermal plate test :

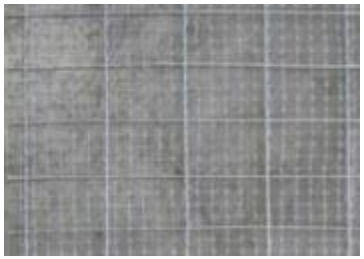


Interlayer system:
reinforcement + bitumen layer

- ⇨ specimen on bed of steel balls for free horizontal displacement;
- ⇨ climate chamber conditioned at -10°C;
- ⇨ slow cyclic opening & closing joint (1mm) by contraction & expansion of loading frame;
- ⇨ Observations:
  - *crack initiation & development (by pictures);*
  - *applied force;*
  - *opening joint (0-1mm);*
  - *relative displacement in overlay (2cm above joint).*

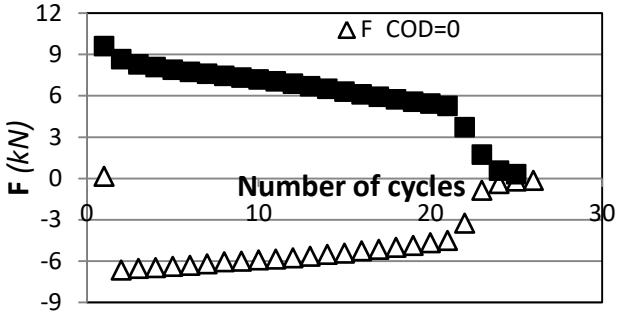
** Operating procedure for thermal cracking test, Belgian Road Research Centre, oct 2010.*

Thermal plate test :

reference - no interlayer	Fortifix® 1-O	Glas grid 35x35
		
+ 300g/m² tack coat	(38x50)kN/m (3100x4400)kN/m + 300g/m² tack coat	(70x100)kN/m (2800x4000)kN/m + 300g/m² tack coat

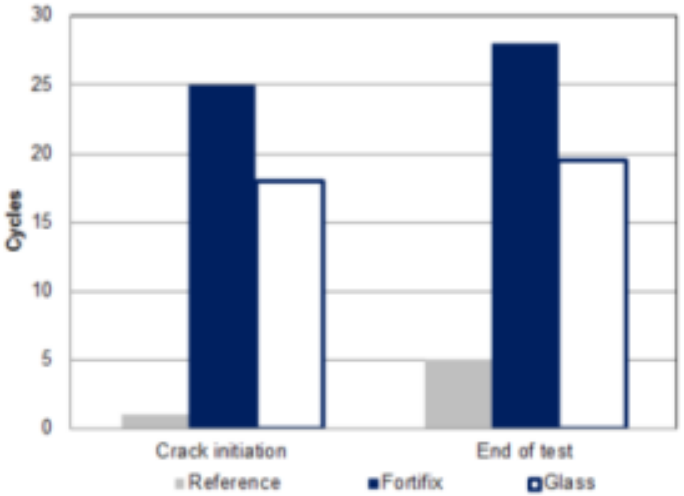
** All tests were done in the same period to make sure there are no differences in used materials.*

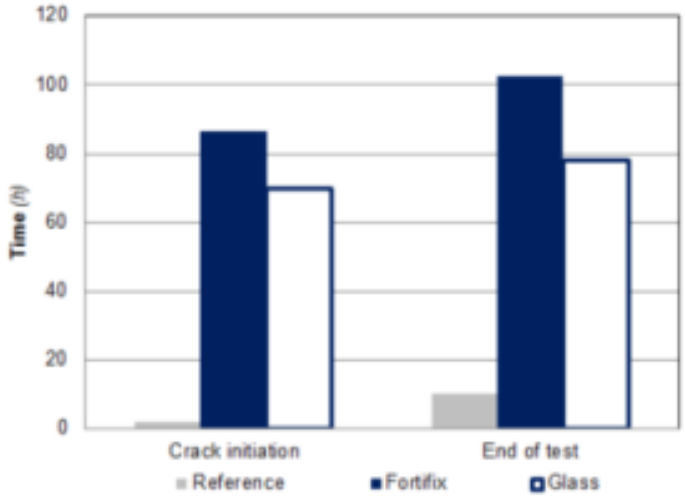
Thermal plate test :



	F_{max} (kN)	Crack initiation		End of test		Remarks
		cycles	time (h)	cycles	time (h)	
Reference	8	1	2	5	10	*crack*
Fortifix	9	Na	Na	Na	130	*no cracks*
	8,7	35	126	35	126	*delamination*
	9,5	15	42	24	90	*crack*
Glas grid	9,6	8	32	11	48	*delamination + crack*
	9,3	28	108	28	108	*delamination*

Thermal plate test :





strength new steel grid = ½ x glas grid & EA is equal

⇨ ***similar/better performance*** *(15-50%)*

Preliminary & unpublished results

What about FF1 & carbophalt?

•	*Reference*	*no interlayer*	*tackcoat*	*300g/m²*	
•	*SAMI*	*SAMI*	*PMB*	*2kg/m²*	
•	*Carbon/glas grid*	*(120x200)kN/m*	*tackcoat*	*300g/m²*	
		(4 000x12 000)kN/m			
•	*FF1-C*	*(42x54)kN/m*	*tackcoat*	*500g/m²*	*(1 sample)*
		(3 000x4 400)kN/m		*700g/m²*	*(2 samples)*

To be submitted for publication in 2019

BEKAERT
better together

Preliminary & unpublished results

What about FF1 & carbophalt?

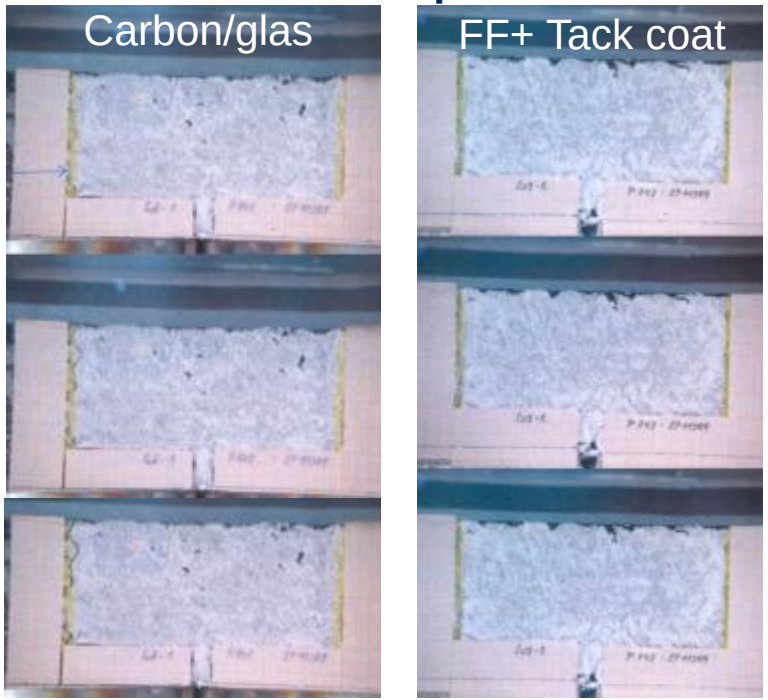
	Tack coat g/m²	F_{max} (kN)	Crack initiation cycles	Crack @ top asphalt cycles	F_{end} (kN)	Remarks
Reference	300	8	1	5	0,04	crack
SAMI	2000	7	1	2	0,04	cracks
	2000	9	1	3	0,08	delamination + crack
Carbon/glas	300	10,5	2	5	2,6	delamination + crack
	300	10	1	5	4,2	crack
FF1-C	500	11,4	2	30	3,7	crack
	700	11,9	1	20	2,8	crack
	700	12	10	50	5,5	crack (not @surface yet)

To be submitted for publication in 2019

BEKAERT
better together

Preliminary & unpublished results

What about FF1 & carbophalt?

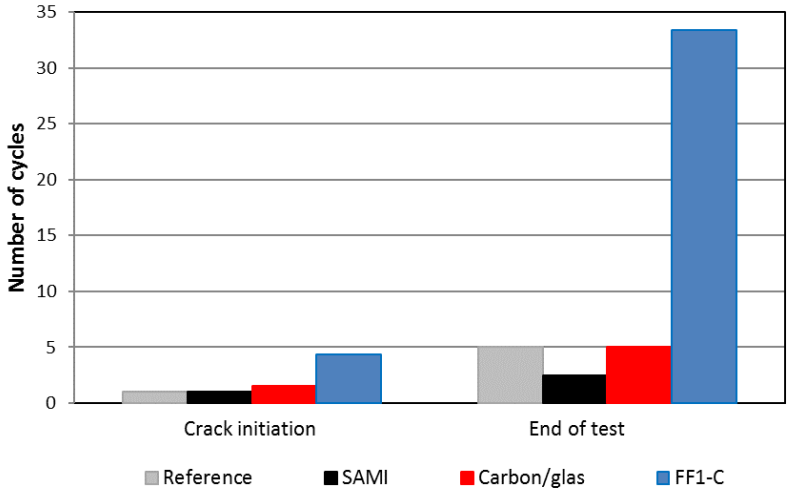


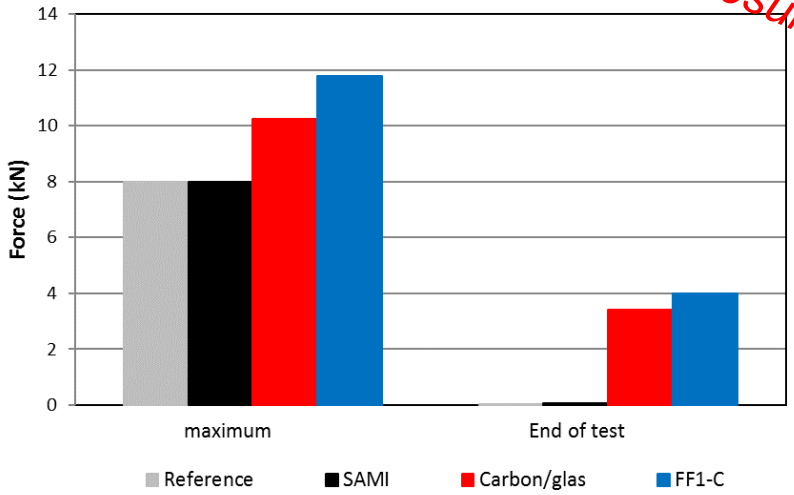
To be submitted for publication in 2019

BEKAERT
better together

Preliminary & unpublished results

What about FF1 & carbophalt?





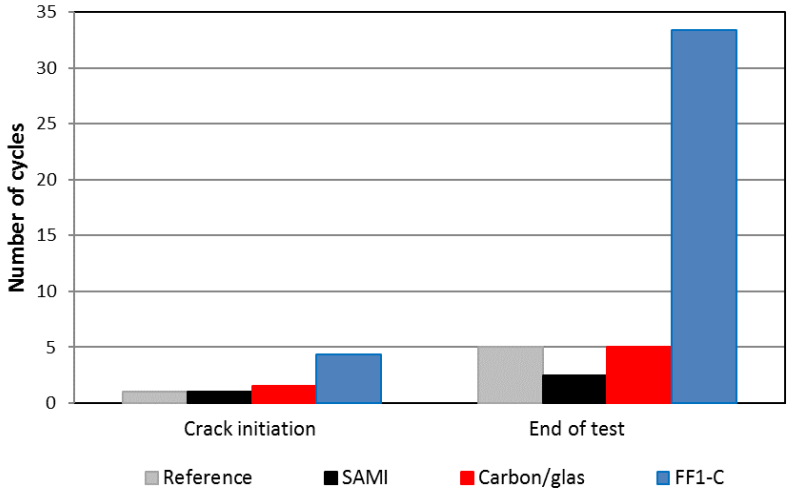
⇨ Both the number of cycles before the end of the test as the maximum force & the force ot the end of the test show a significant effect on preventing crack initiation and crack growth.

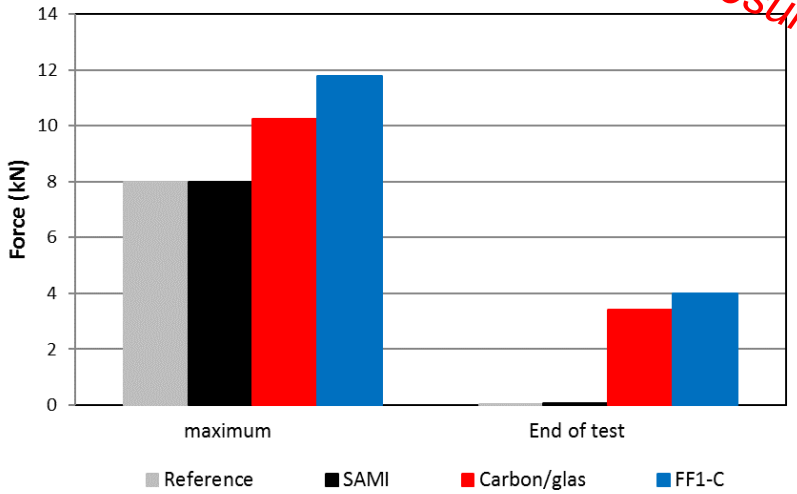
To be submitted for publication in 2019

BEKAERT better together

Preliminary & unpublished results

What about FF1 & carbophalt?





Athough FF = 1/4 x carbon grid & EA FF = 1/3 x carbon grid

⇨ ***better performance based on crack propagation & Force take-up***

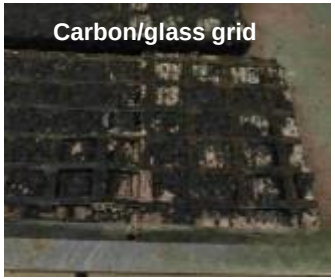
To be submitted for publication in 2019

BEKAERT
better together

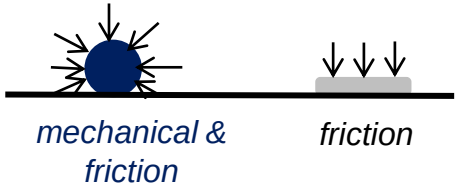
Preliminary & unpublished results

How can this be explained?

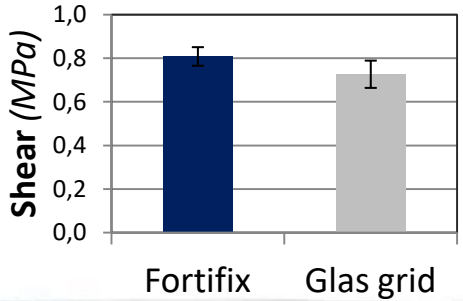
1. Adhesion to overlay :



Interlocking 3D structure ensures anchorage;



2. Adhesion existing surface & overlay:



Shear test:

limited reduction surface by steel compared to glass

⇨ *adhesion interface is less influenced*

To be submitted for publication in 2019

BEKAERT better together

BEKAERT
better together