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Polymer Modification Impact on Chip Seal Asphalt Binder Residue Aging and Laboratory Protocols

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COLAS

Outline

- Background of some Colas Chip Seal experience
- Curing Vs. Aging
- Existing standards to simulate curing and aging
- Environmentally Aging Testing protocol
- Laboratory Stabilized Vs. Environmentally Aged:
  - Asphalt grade /source, Dosage, Polymer ratio, Emulsions, MSCR and weather
- Conclusions and considerations

Background: Hot Applied Chip Seal

- 2004 – 2006: Colas Developed Vegeflux®, a bio-flux used in Hot Applied Chip Seal but also any other Pavement Preservation technique
- 2006 – 2012: Deployment on the European Market and Return of Experience
- **Safer** for the user, **Sustainable**,

and **Eco-Responsible**, **Carbon Sink**

- Stiffening by oxidation/polymerization compare

to loss of volatile from petroleum fraction

- Curing and Aging critical !
- Immediate adhesion = High traffic level

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Background: Cold Applied Chip Seal

- Asphalt Emulsion preferred in the Chip Seal techniques in Colas
- **… Col**d **As**phalt = **COLAS … 1929 Shell Patent**
- Safer handling, lower energy consumption relative to heat
- Less solvent to none relative to the season
- Better wettability with the aggregates
- Forgiving technique with optimal viscosity
- Viscosity challenges (PMAC, AC base, emulsifiers, etc.)
- Slow Curing the first day = Low to Medium Traffic level

- Hot Vs Cold Applied Chip Seal curing and aging ?

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Hot & Cold Applied Chip Seal

- What are the difference between Curing and Aging for chip Seals?

Curing: *necessary time for the binder to reach the performance of the "original" binder after volatilization of petroleum-based solvent or polymerization of bio-solvent for Hot Applied binders or for the water to be expelled and evaporate with its solvent for an emulsion.*

Aging: *Hardening above original binder performance, from oxidation with oxygen, UVs, temperatures, weathering, and traffic.*

- What are the risk if Curing is too slow ?
  - A LOT…
- What are the risk if Aging is too fast?
  - NOT a lot…

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Testing Standards

- 1993 – 2010 : **French Standard NF T66-031** - Determination of kinetic of anhydrous and bitumen emulsion binders stabilization
  - *Method at 50 °C for 14 days*
- 2006: **European Standard EN 13074**: Bitumen and bituminous binders - Recovery of binder from bituminous emulsion…
  - *Part 1: Recovery by evaporation for 24 hours at ambient temperature and 24 hours at 50 °C*
  - *Part 2: Stabilization after recovery by evaporation for 24 hours at 85 °C*
- **AASHTO R 78 / ASTM D7497-21**: Recovering Residue from Emulsified Asphalt Using Low-Temperature Evaporative Technique
  - *A - 24 hours at 25 °C and 24 hours at 60 °C , 1 mm residue thickness*
  - *B - 6 hours at 60 °C, 0.25 mm residue thickness*
- **AASHTO R28** - Residue PAV…
- Coming **SPG / EPG Specifications** …

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afnor NORMALISATION

AASHTO

ASTM INTERNATIONAL

European Standard EN 13074

- Bitumen and bituminous binders - Recovery of binder from bituminous emulsion or cut-back or fluxed bituminous binders
- Part 1: Recovery by evaporation for **24 hours at ambient** temperature and **24 hours at 50 °C**

  ⇒ Fresh binder performance (1 to 2 days on the field)

- Part 2: Stabilization after recovery by evaporation for 24 hours **at 85 °C**

  ⇒ Binder performance after curing (missing time scale)

- Limitations

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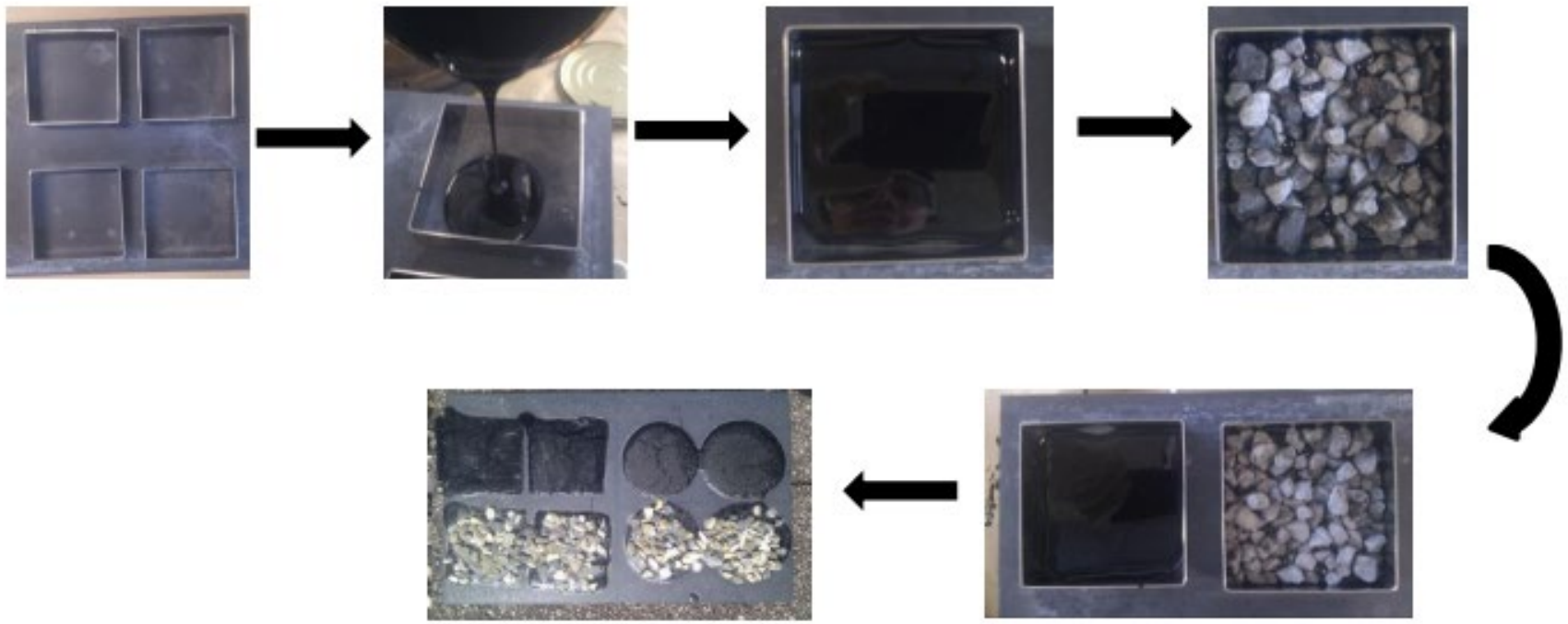
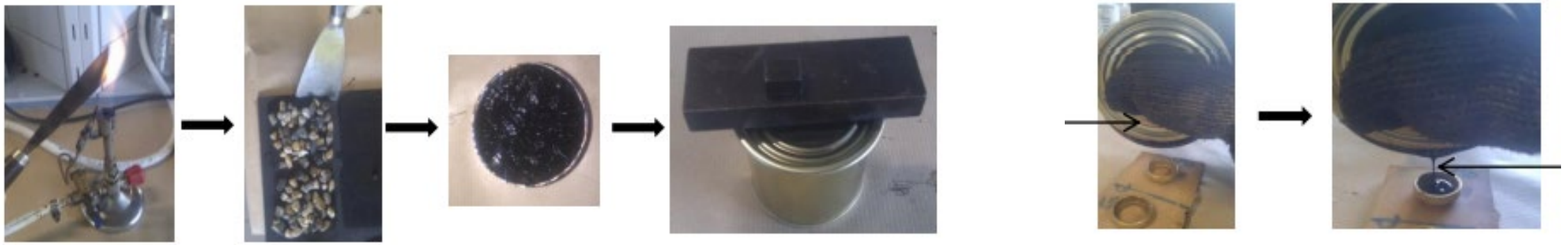
Environmentally Aging Test (EAT): Protocol

- Principle: To expose chip seal binder in real weather condition following dosage rate of the EN 13074 of 1 kg/m^2
- With and without 6/10 mm aggregate



Environmentally Aging Testing (EAT)- Protocol

- With a hot spatula , the binder is scraped with and without aggregate at the due date
- Poured into a pen cup with a lid and heat at 120˚C for 30 minutes
- The lid helps for retaining the aggregates for pouring into the ring and ball or DSR mold



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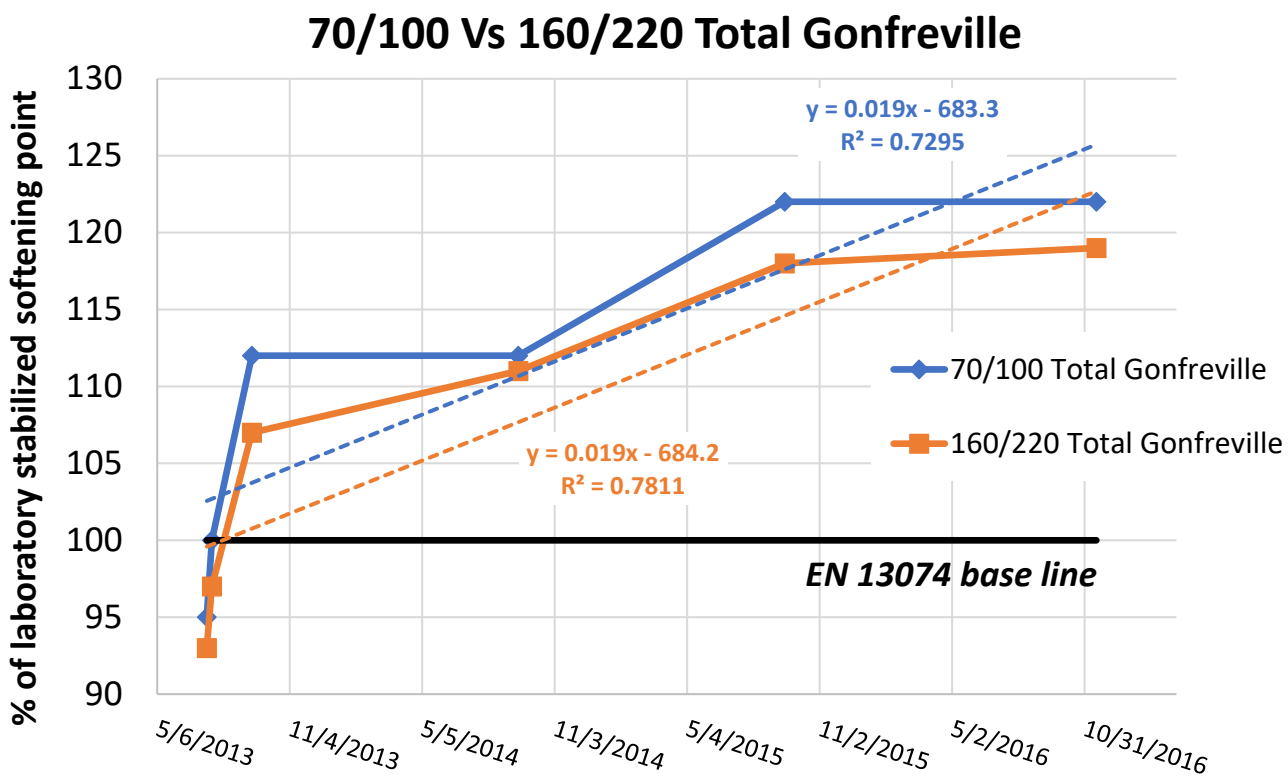
EN 130074 Stabilized binder Vs. EAT : Asphalt Grade

- Same asphalt source / different grades / Without Aggregates



Binder Total Gonfreville Grade	70/100	160/220
Laboratory Stabilized Binder EN 130074 Softening Point (˚C)	49.0	42.8

→ Neat asphalt stabilize predictably fast

→ 14 days EAT equivalent => 70/100

→ 1 month EAT equivalent => 160/220

→ Softer asphalt base, longer stabilization

Same Asphalt Source, Same Aging Ratio

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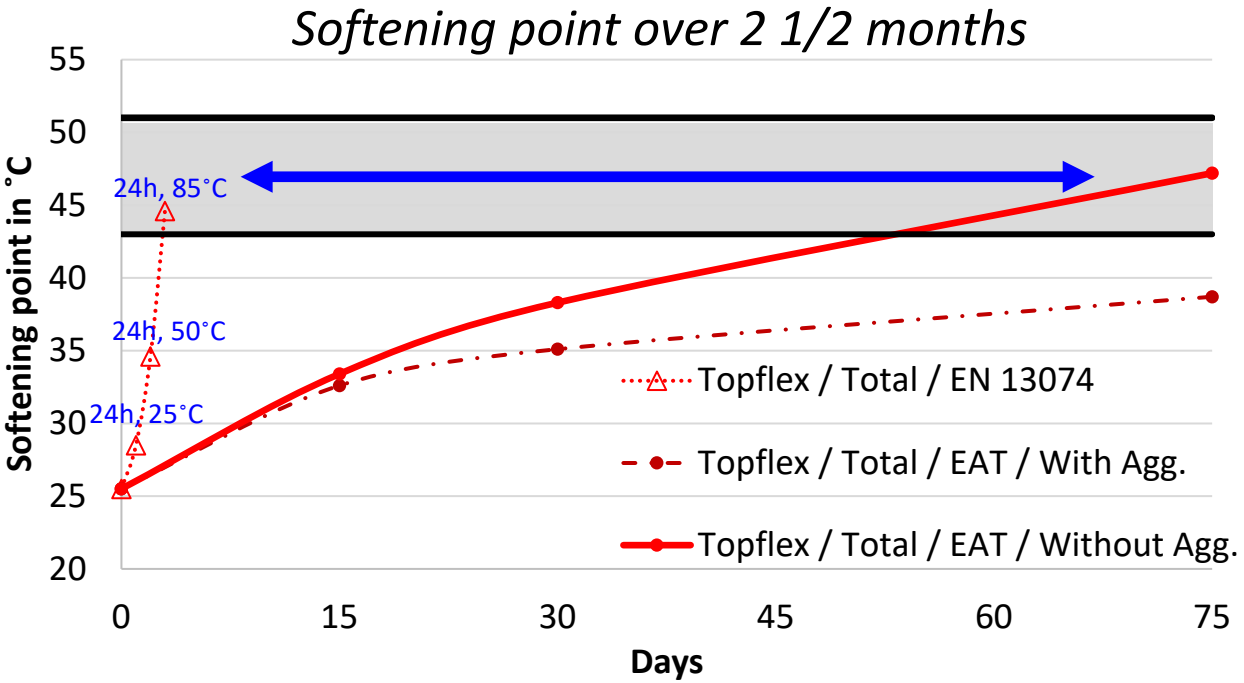
EN 130074 Stabilized binder Vs. EAT : Solvent-Based Binder

- Softening Point of Stabilized Binder by EN 13074 and environmentally aged with and without aggregates



→ Penetration grade 70/100

→ 43 to 51°C Softening point range

→ Solvent based by EN 13074 validated

→ Without aggregate

→ Quid of the equivalent time lab Vs. field for the binder to cure with the original softening point range

→ Longer curing with Aggregate = Post construction risk

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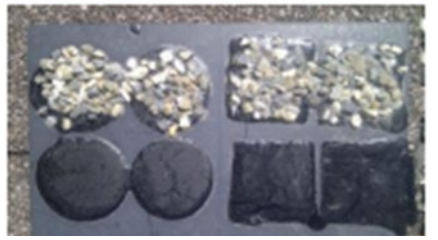
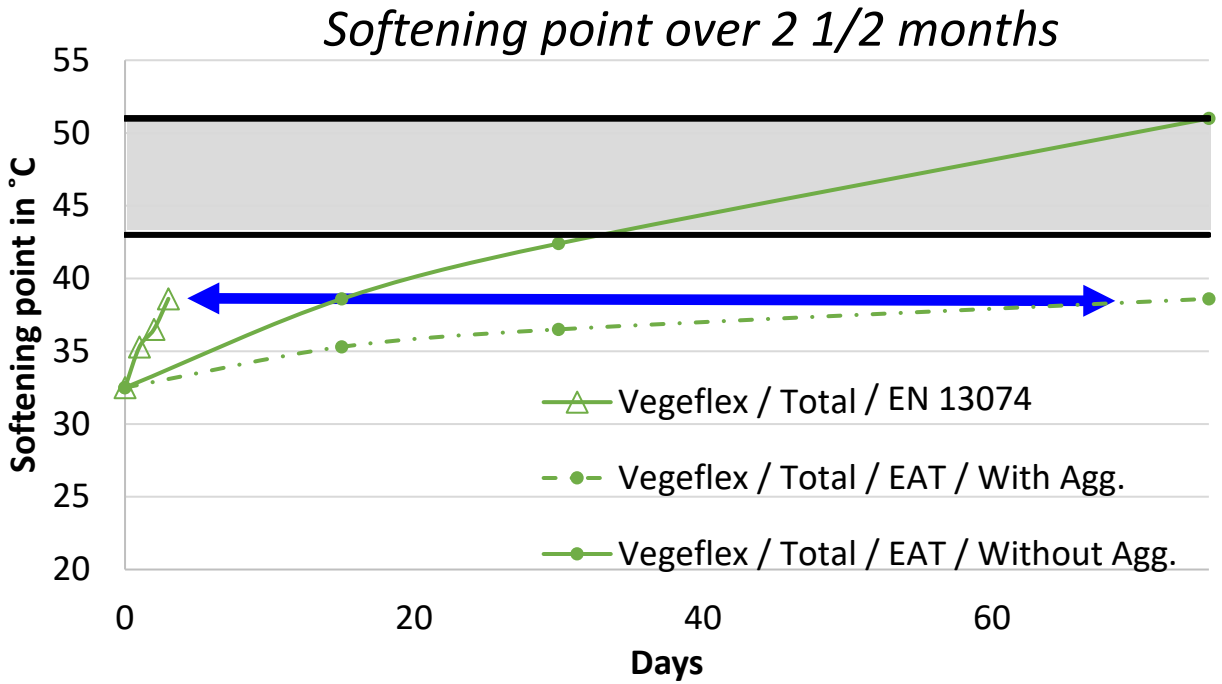
EN 130074 Stabilized binder Vs. EAT : Bio-Based Binder

- Softening Point of Stabilized Binder by EN 13074 and environmentally aged with and without aggregates





→ Penetration grade 70/100

→ 43 to 51°C Softening point range

→ Bio based by EN 13074 validated

→ With aggregate

→ Lab stabilization needs to be extended with bio-based binder

→ Longer curing with Aggregate = Post construction risk

Rest of the study conducted **with Aggregates** for field representativity

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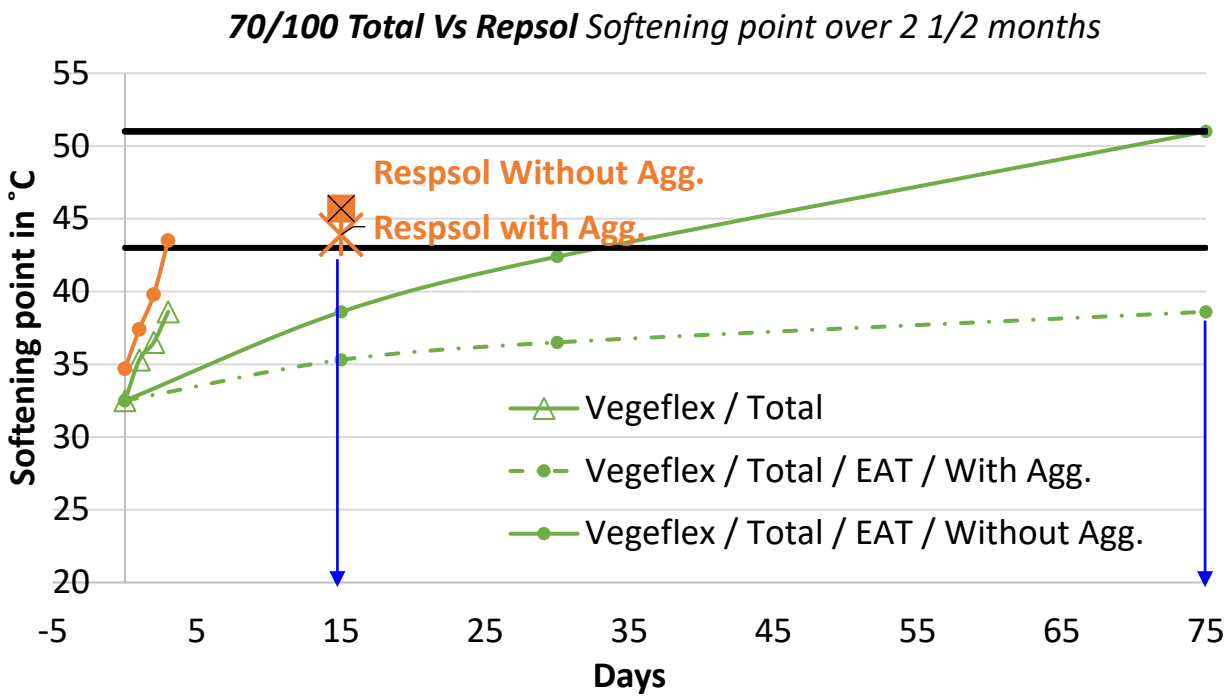
Laboratory Stabilized Vs. EAT: Asphalt Source

- Softening Point of Stabilized Binder by EN 13074 and environmentally aged with and without aggregates



→ Penetration grade 70/100

→ 43 to 51°C Softening point range

→ Vegeflex curing with Agg. &Total: +3 months

→ Vegeflex curing with Agg. &Repsol: 15 days

Curing is Asphalt Source Relative

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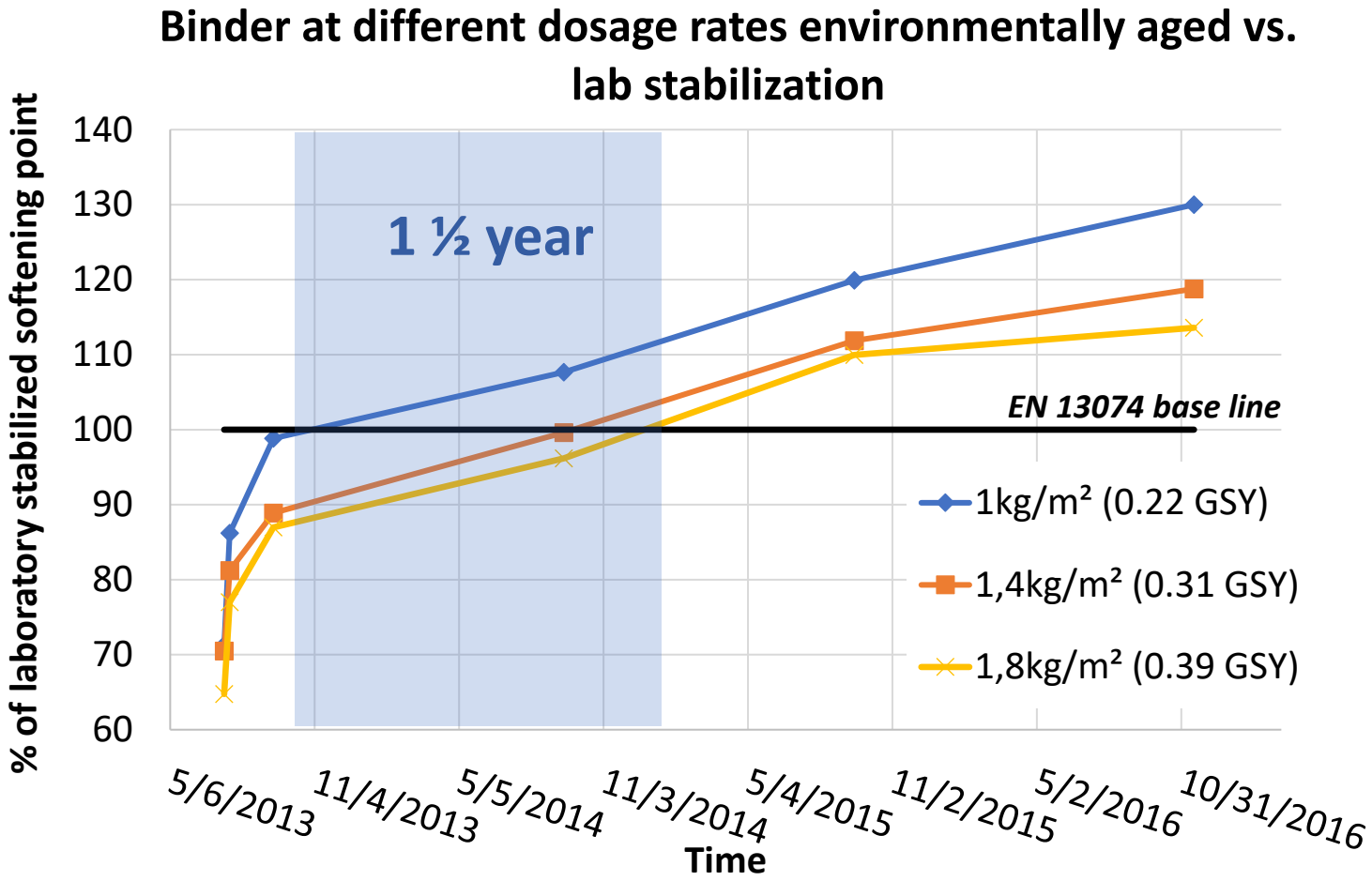
EN 130074 Stabilized binder Vs. EAT: Dosages



→ Solvent-based Binder + Agg.

→ 1 kg/m² = 1 mm => Testing condition

→ 1.4 to 1.8 kg/m² => Field condition

→ 6 months to 1 ½ year difference

→ Higher film thickness, Longer stabilization

Lab Stabilization not representative of "*field curing with Aggregates*" condition

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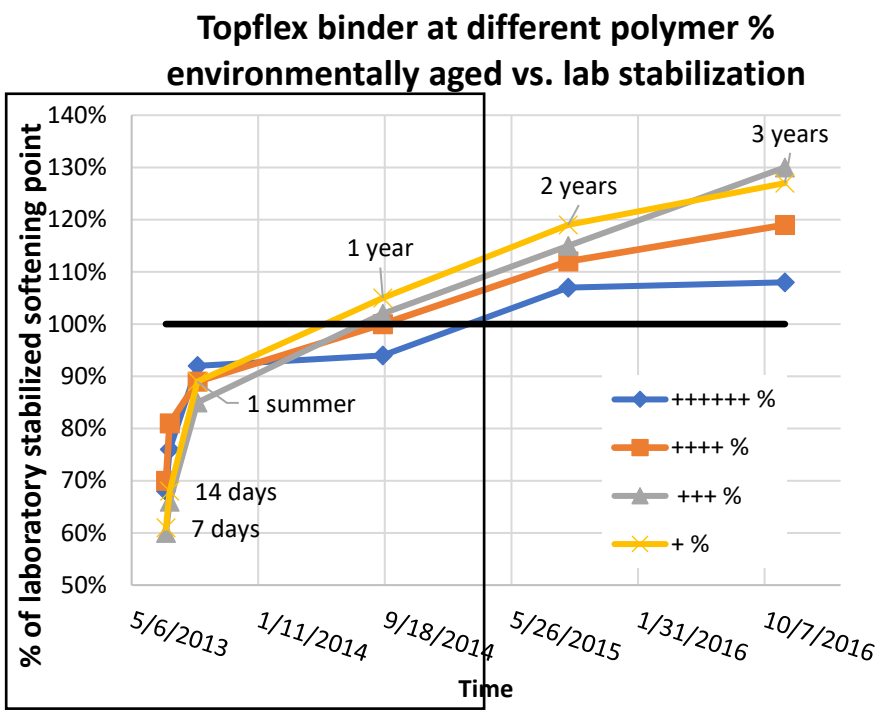
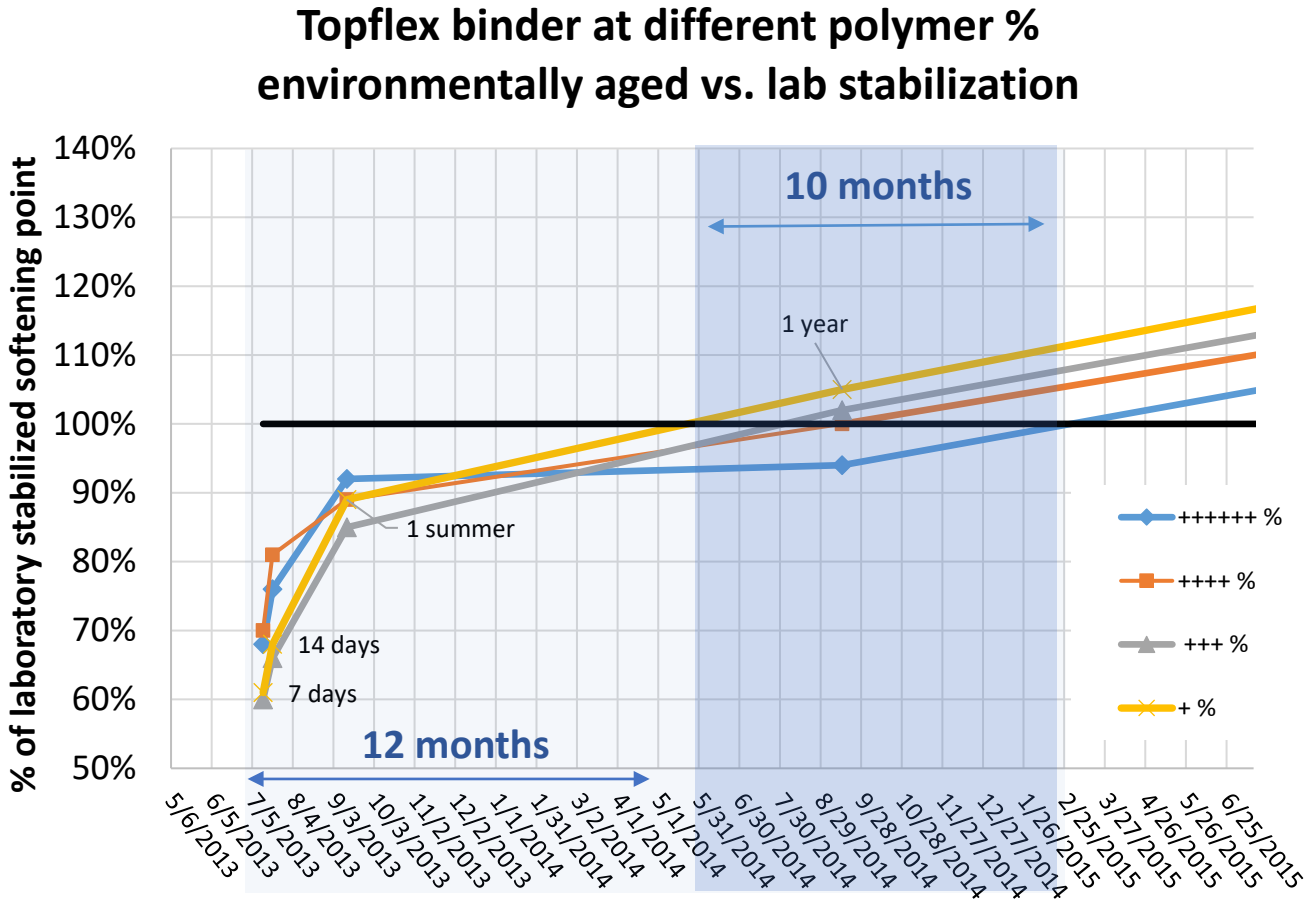
EN 130074 Stabilized binder Vs. EAT: Polymer %





→ Hot Applied, 1,4kg/m² (0.31 GSY)

→ Solvent-based / Aggregates

→ 10 to 22 months to reach 100% lab stabilized performance

Curing relative to % Polymer

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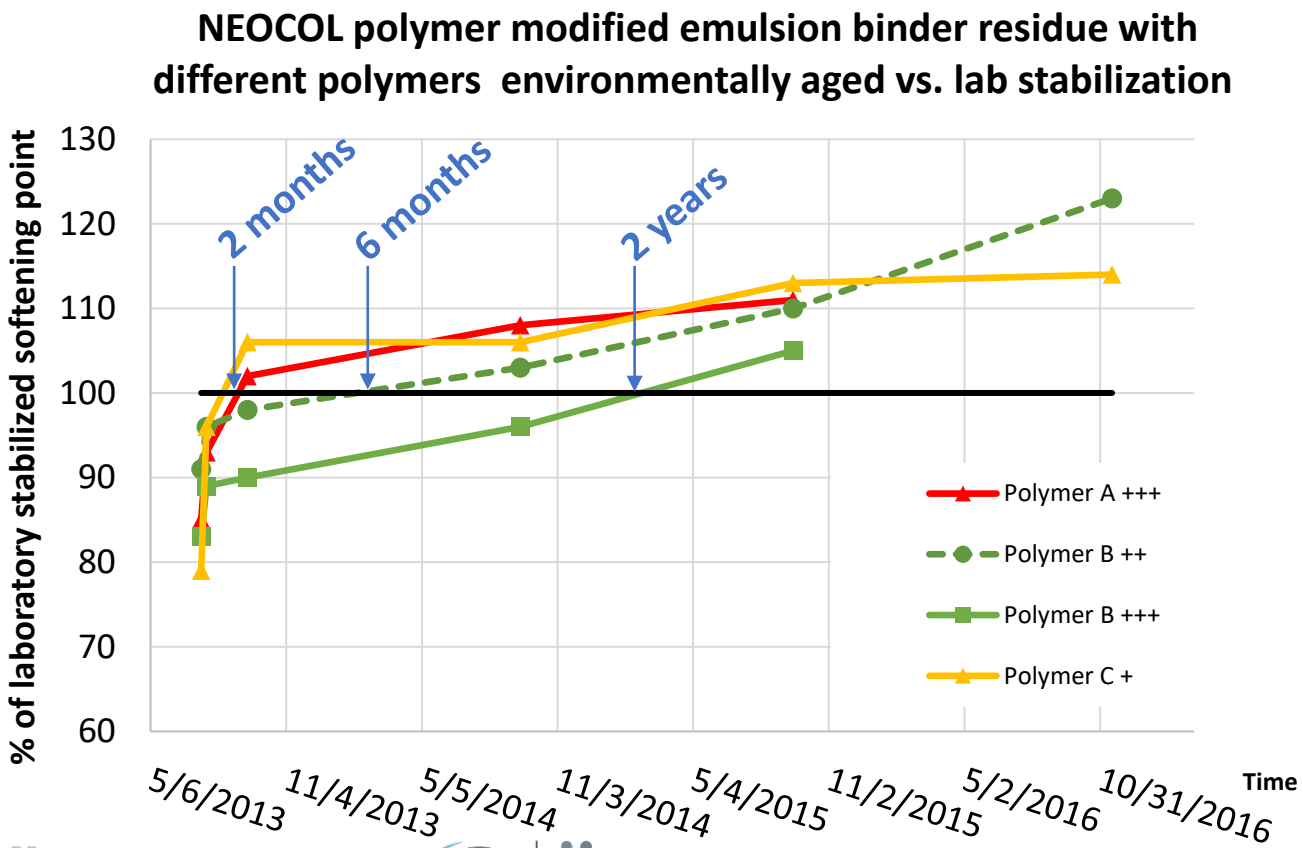
EN 130074 Stabilized binder Vs. EAT : Asphalt Polymer Modified Emulsion

- Polymer Type / Polymer Dosage/ Emulsion dosage of 1.8 kg/m²



→ 1.8 kg/m² Emulsion => 1.2 kg/m² binder residue

→ 2 months to 2 years curing depending polymer type and polymer ratio

→ Laboratory Stabilization not representative of "field curing" condition

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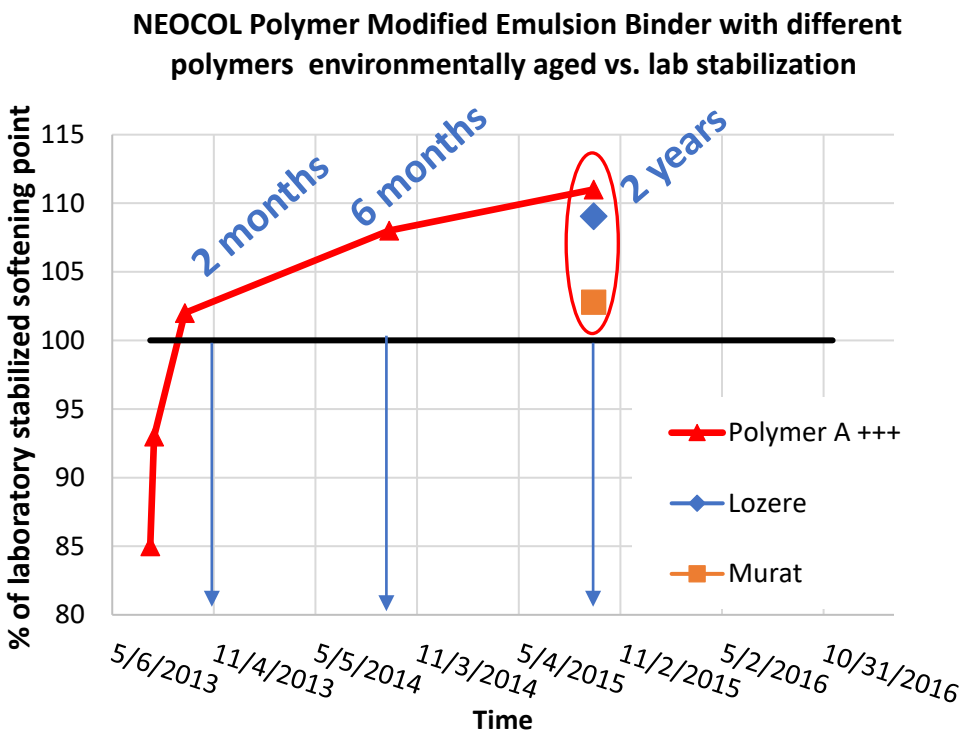
EN 130074 Stabilized binder Vs. EAT : Field comparison

- Polymer Type / Polymer Dosage/ Emulsion dosage of 1.8 kg/m^2



→ Sampling from 2 years old jobsite

→ Same emulsion formula with A +++

→ Lozere Softening Point (SP)of 62.6°C

→ Murat SP of 59.0°C

→ EN 13074 stabilization SP of 57.4°C

Environmentally Aged sample at the laboratory is representative of field curing condition

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EN 130074 Stabilized binder Vs. EAT : : MSCR at 64°C

Jnr 3.2 kPa (kPa^{-1}) at 64 °C										
	Topflex Polymer Modified Binder						Neocol - Polymer Modified Emuslion			
Dosage rate (kg/m^2)	1.4	1.4	1	1.4	1.8	1.4	1.2	1.2	1.2	1.2
Polymer Level	+ Low	+++ Med.	++++ High	++++ High	++++ High	++++++ Very High	A +++ High	B ++ Med.	B +++ High	C + Low
1 years	5.9	5.3	0.5	3.2	4.2	3.2	2.4	5.7	5.6	6.8
3 years	0.8	0.9	Too Stiff to recover	0.6	1	Too Stiff to recover	1.1	2.8	2.8	6.2

SPG at Temp. Maximum Jnr @3.2 kPa	Traffic Level
< 8 kPa^{-1}	Low (0-500 ADT)
< 5.5 kPa^{-1}	Medium (500-2500 ADT)
< 3.5 kPa^{-1}	High(> 2500ADT)

→ Comparing to recent SPG Jnr specifications, residue are formulated for low and high ADTs

→ Medium ADTs with intermediate polymer dosages will be challenging as curing seems dependent of Polymer Nature, type, Lab aging ?

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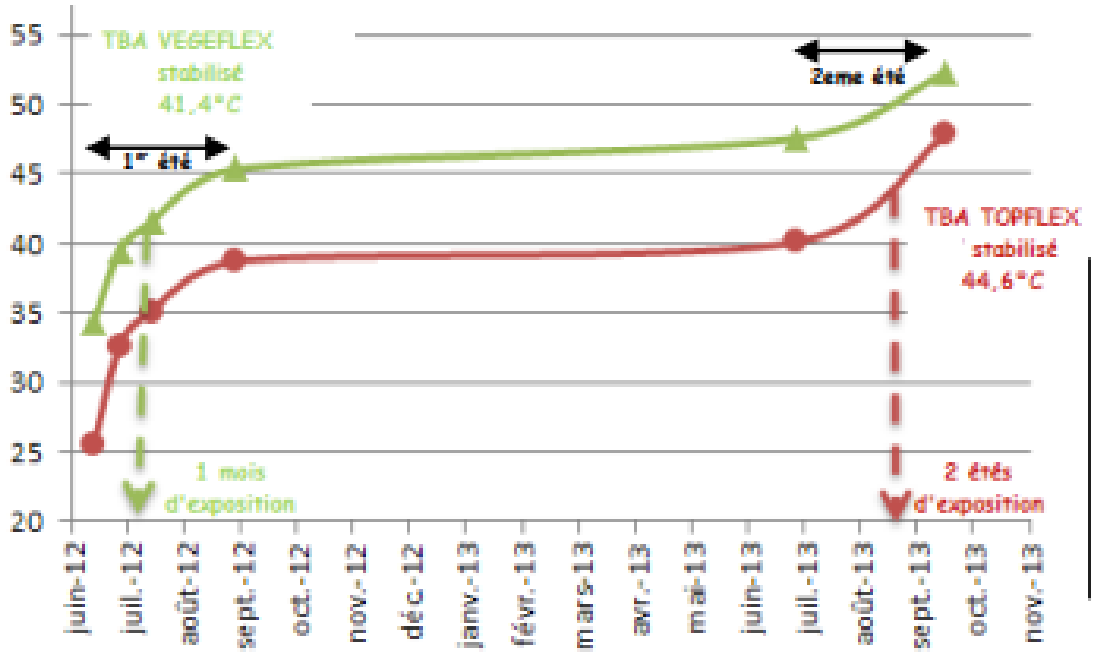
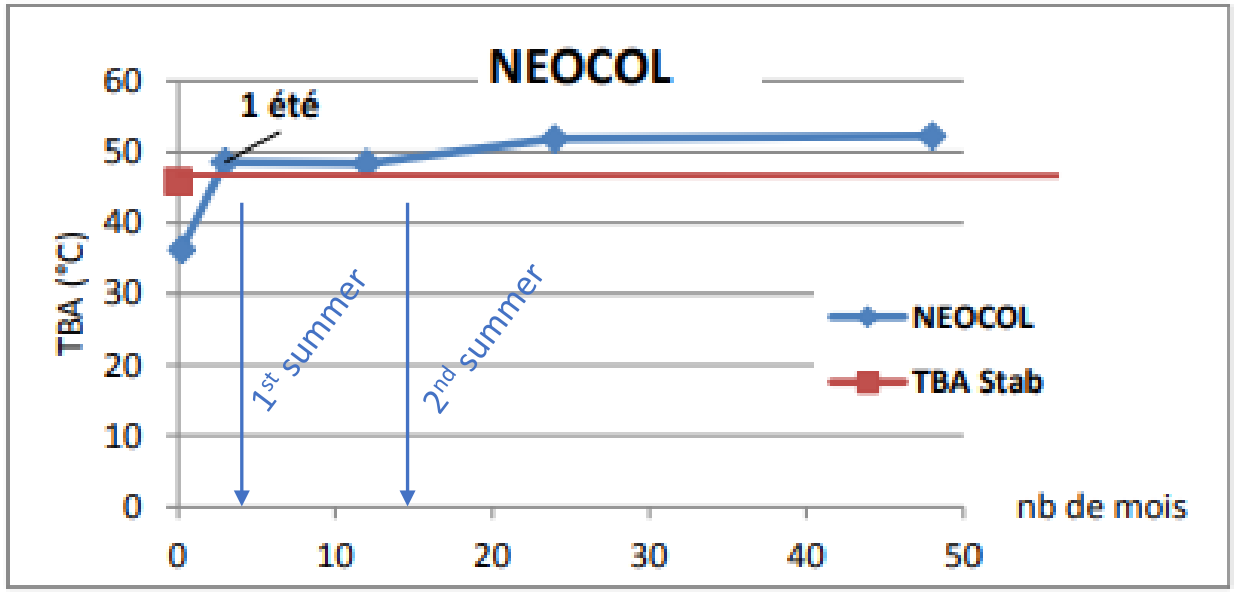
EN 130074 Stabilized binder Vs. EAT : Climatic variations





→Hot Applied required up to 2 summers

→Emulsion only 1 summer with the proper polymer

Summer curing is critical for durable chip seal

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Conclusion

- Focus on post-construction curing, most critical stage for durable chip seal
- European Stabilization EN 13074 (24hours @ 25°C, 24hours @ 50°C, 24hours @ 85°C) is considered to simulate curing on the field

- The environmentally Aging Test demonstrates that curing is relative to :

  - **Hot applied Solvent/Bio-Based or Cold Applied Emulsion**
  - **Binder dosage:** Heavier, slower the curing
  - **Asphalt Source and Grade:** 2 weeks to 2 months curing delay
  - **Polymer type:** 2 months to 2 years curing delay
  - **Polymer / binder ratio**: 2 months to 2 years delay
  - **Summer Curing** : 1 months of hot temperature to secure the job through the winter

- European Stabilization EN 13074 is not equally “CURING TIME” representative for different binders (15 days to 2 years depending hot or cold applied, formulation and application rate)

- Environmentally aged samples seems to be representative of field curing over 2 years

- Polymer Modified Binder curing behaviors needs to be further investigated before to create specifications

Considerations

- This study conducted from 2012 to 2016 and did not consider the SPG and EPG specifications at that time unfortunately
- EPG and SPG working group are discussing the Long-Term Aging
- Long Term Aging after curing is interesting but not necessary as binder residues stiffness reach quickly a plateau
- Chip seal generally also fail within the first year (dirty agg., bonding issues, too cold temperature, dosage, too stiff binder to start, etc,) and mostly after the first winter exacerbating the problems
- Chip seal rarely fail after 3 years because the AC became too stiff. Even with polymerization of bio-based binders.
- Chip Seal durability is highly dependent of the job preparation, Aggregates cleanliness, crew competency, etc.
- Many time it is just not the right technique because the owner has been waiting too long…

Any Questions ?

Be safe, Thank you

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