

Pavement Analysis using FlexPAVE

Damage evolution results - additive's life extension benefits

Mix ID	Months to reach 5% damage	Life extension compared to Control, months
Control Binder 1	24	0
Binder 1 + Additive 1	30	6
Binder 1 + Additive 2	62	38
Binder 1 + Additive 3	222	198
Binder 1 + Additive 4	22	-2
Binder 1 + Additive 5	34	10

Mix ID	Months to reach 8% damage	Life extension compared to Control, months
Control Binder 5	51	0
Binder 5 + Additive 1	148	97
Binder 5 + Additive 2	72	21
Binder 5 + Additive 3	212	161
Binder 5 + Additive 4	30	-21
Binder 5 + Additive 5	78	27

Conclusions

- The effectiveness of the aging-resistant additives varied based on the base binder and the presence of RAP.
- All five additives helped reduce the negative effects of aging in both neat and their blends with RAP.
 - However, they proved more effective in Binder 1 (m-controlled, more negative ΔT_c), where improvements in the phase angle directly translated to better low-temperature performance.
- Although no direct evidence indicates that these additives slow oxidation kinetics, they may offer significant benefits in stabilizing low-quality virgin binders or brittle RAP binder blends.
- While the additives were selected for their aging-resistant potential to disrupt and decelerate oxidation, which leads to the formation of ketones (carbonyl groups), the complex nature of asphalt oxidation has long resisted a purely chemical solution.
 - Instead, the most practical strategy involves using age-stable rheological modifiers that restore molecular mobility and enhance relaxation properties where needed most.

Thank You

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