

NCHRP Project 20-07 / Task 400

Effect of Elevation on Rolling Thin Film Oven Aging of Asphalt Binder

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"Engineering Services for the Asphalt Industry"

Lots of Help

- Dave Anderson
- Jim Rosenberger
- Gayle King
- John Malusky
- Shauna Teclemariam
- Volunteer Labs

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Outline

- Objectives
- Approach
- Work Completed
- What's Next



Objectives

- Confirm or refute previous studies showing an elevation effect in properties of RTFOT residue

And if there is an effect and it is of engineering significance then....

- Improve the AASHTO T 240 procedure to minimize differences in physical properties of RTFOT residue obtained at different elevations.



Approach

- Perform statistical and engineering analysis of available data:
 - Western Cooperative Testing Group
 - AASHTO Resource Proficiency Samples
- Select method to minimize elevation effect
- Design, execute, and analyze an experiment to confirm viability of the selected method
- Prepare documentation
 - Recommended modifications to AASHTO T 240 with commentary
 - Report with data files



Statistical Analysis

- Western Cooperative Testing Group
 - 11 binders, 1 neat, 10 modified
 - 40 labs, 1 replicate
 - 441 observations
 - 12 to 6,720 ft elevation range (uniform distribution)
- AASHTO Resource
 - 4 binders, 2 neat, 2 modified
 - 213 labs, 2 replicates
 - 1700 observations
 - 0 to 6,295 ft elevation range (68 % below 1,000 ft)



Statistical Analysis

- Properties
 - Original $G^*/\sin\delta$
 - RTFOT $G^*/\sin\delta$
 - Aging Index
 - $J_{nr3.2}$
 - $R_{3.2}$
 - Mass Change

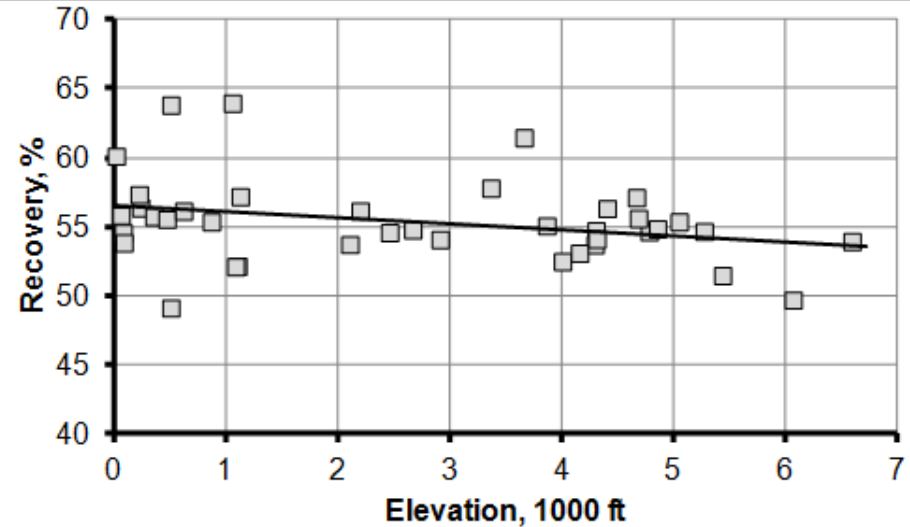
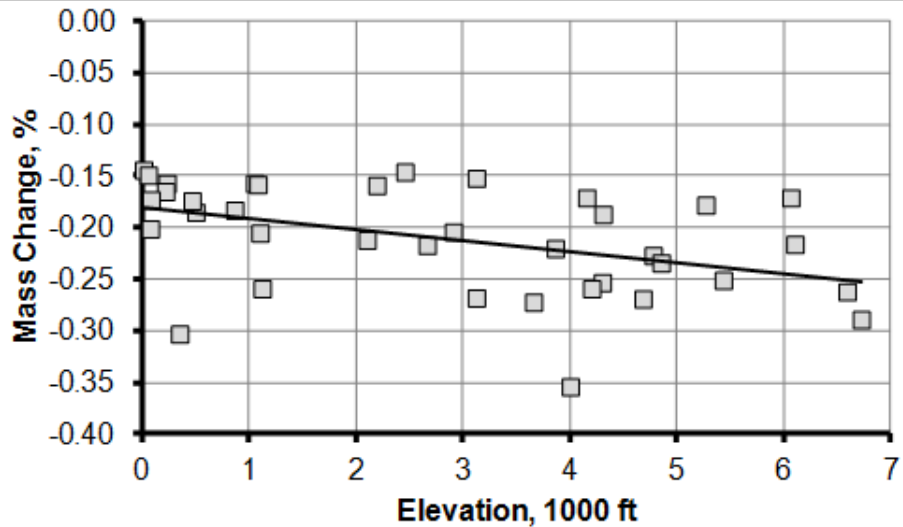
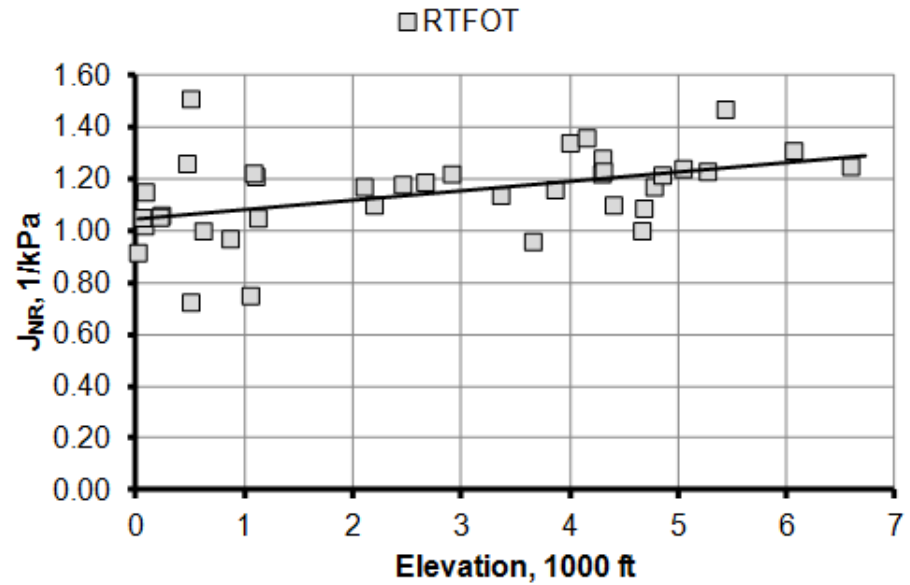
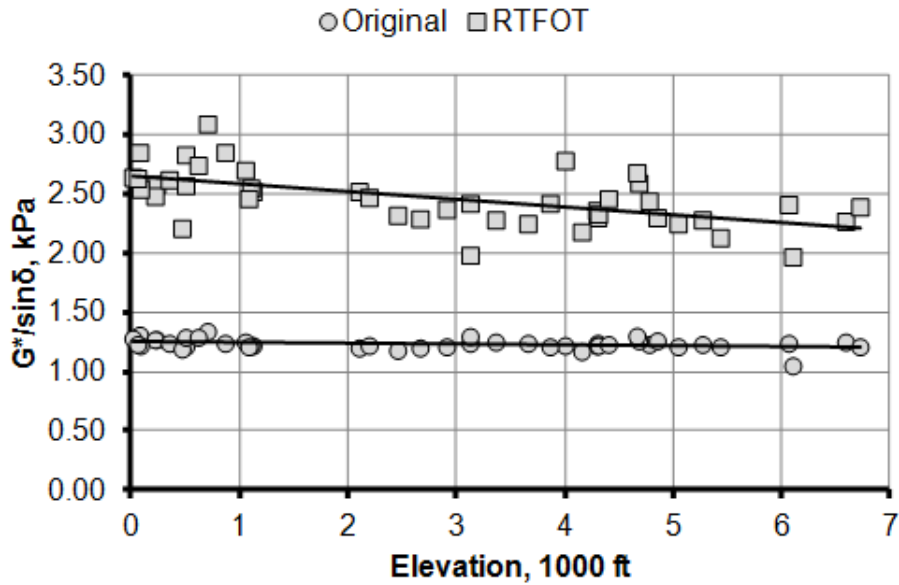


Statistical Analysis

- Approach
 - Assemble data
 - Graphical analysis
 - Systematic identification of outliers
 - Initial regression analysis as a function of elevation allowing binder dependent slopes and intercepts
 - Remove data having standardized residuals exceeding ± 2.5
 - Final regression analysis
 - Significance of elevation effect
 - Binder dependency
 - Performed by Consulting Statistician

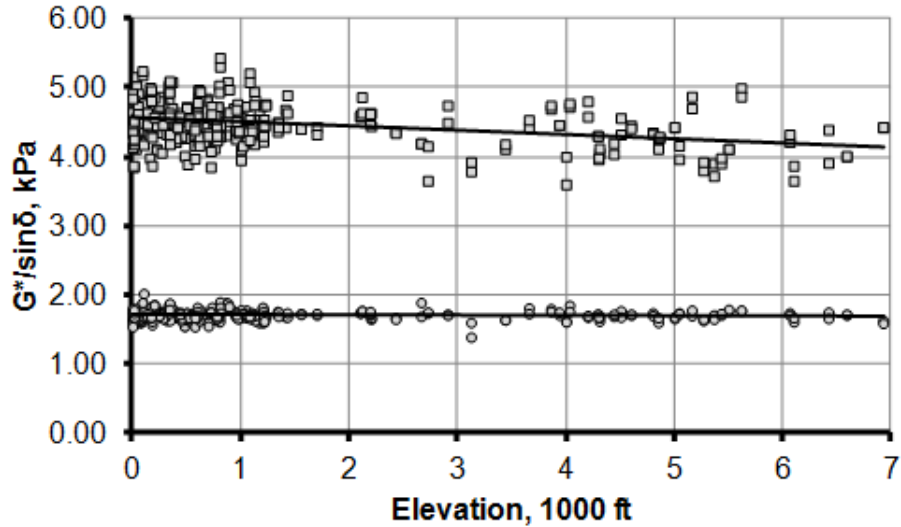


WCTG Binder 552

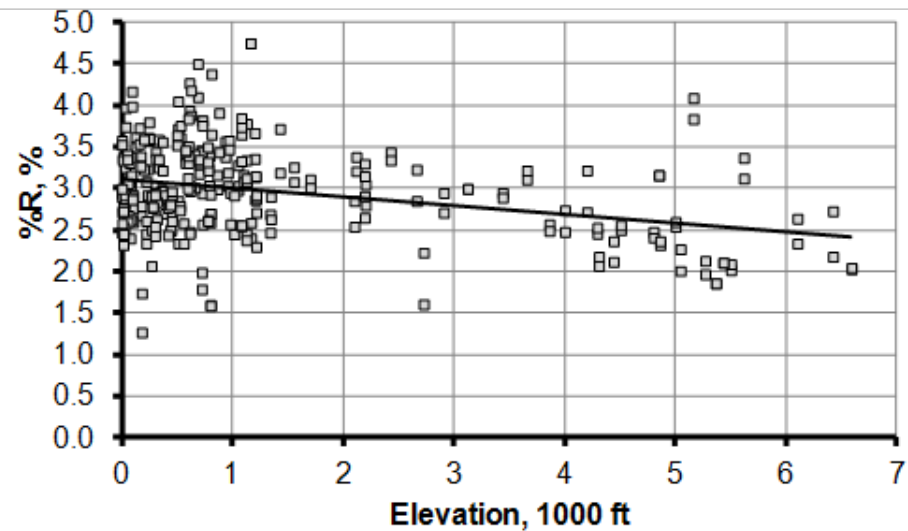
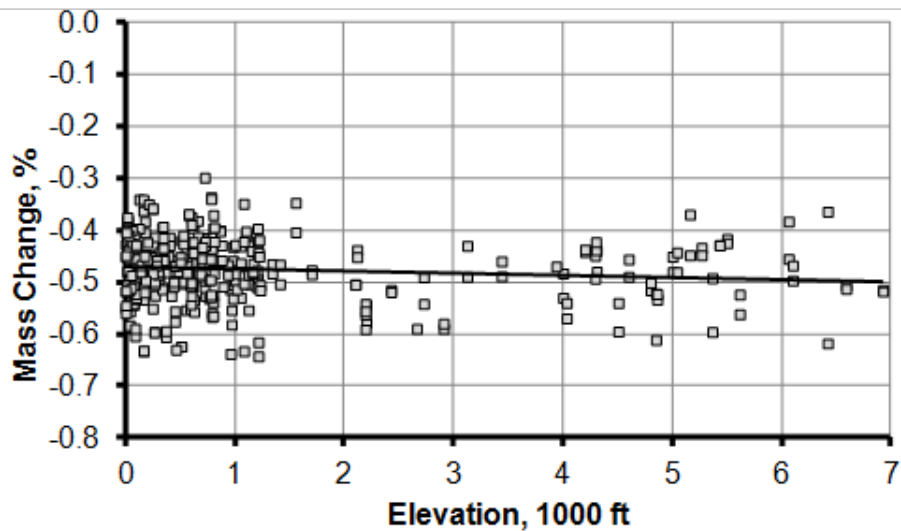
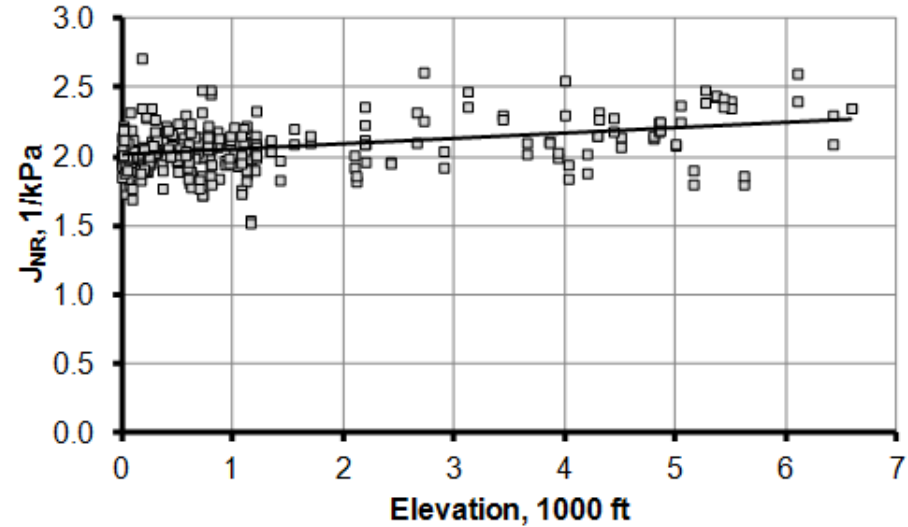


AASHTO Resource 235/236

○ Original □ RTFOT



□ RTFOT

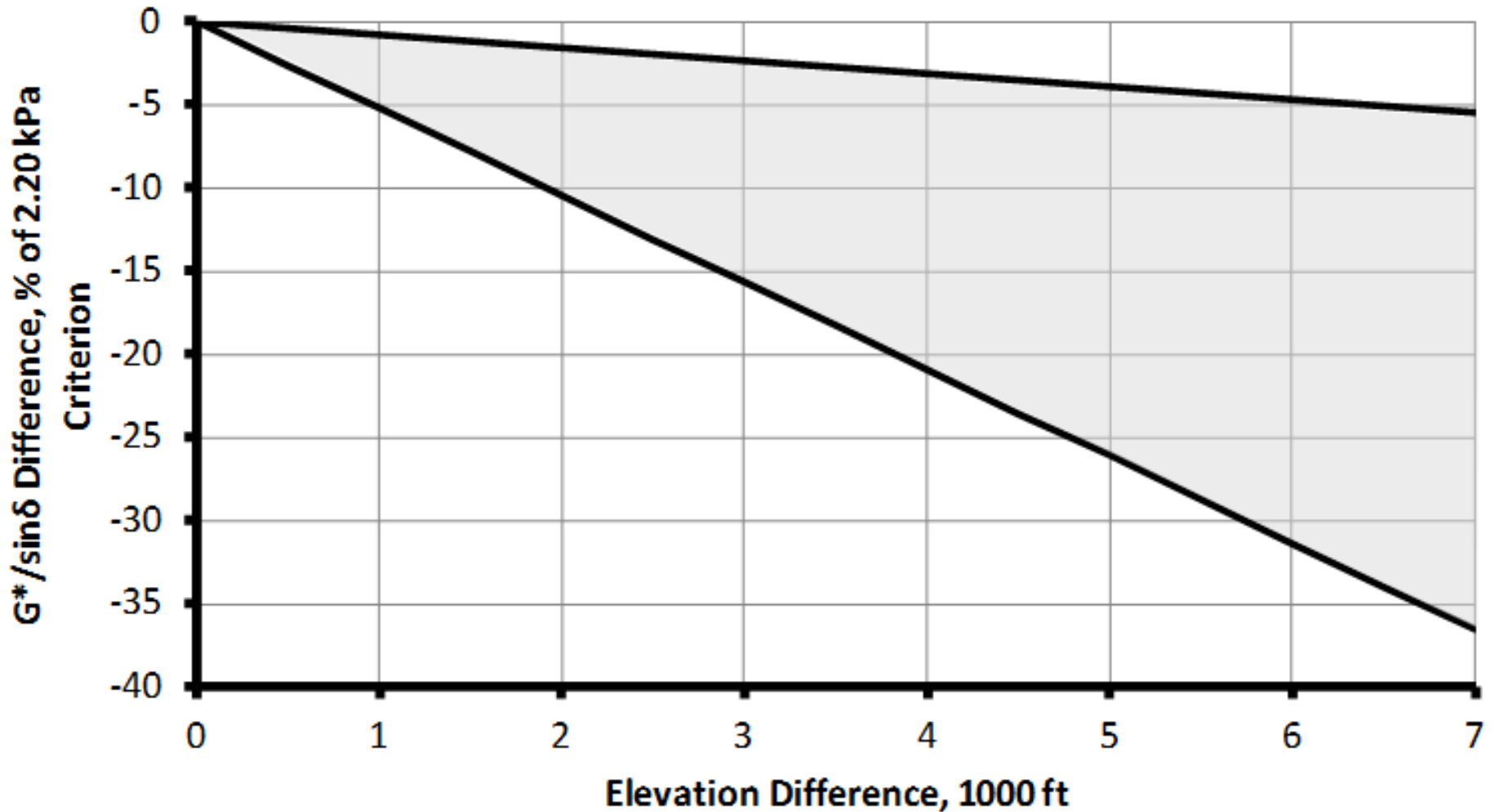


Summary of Statistically Significant Effects

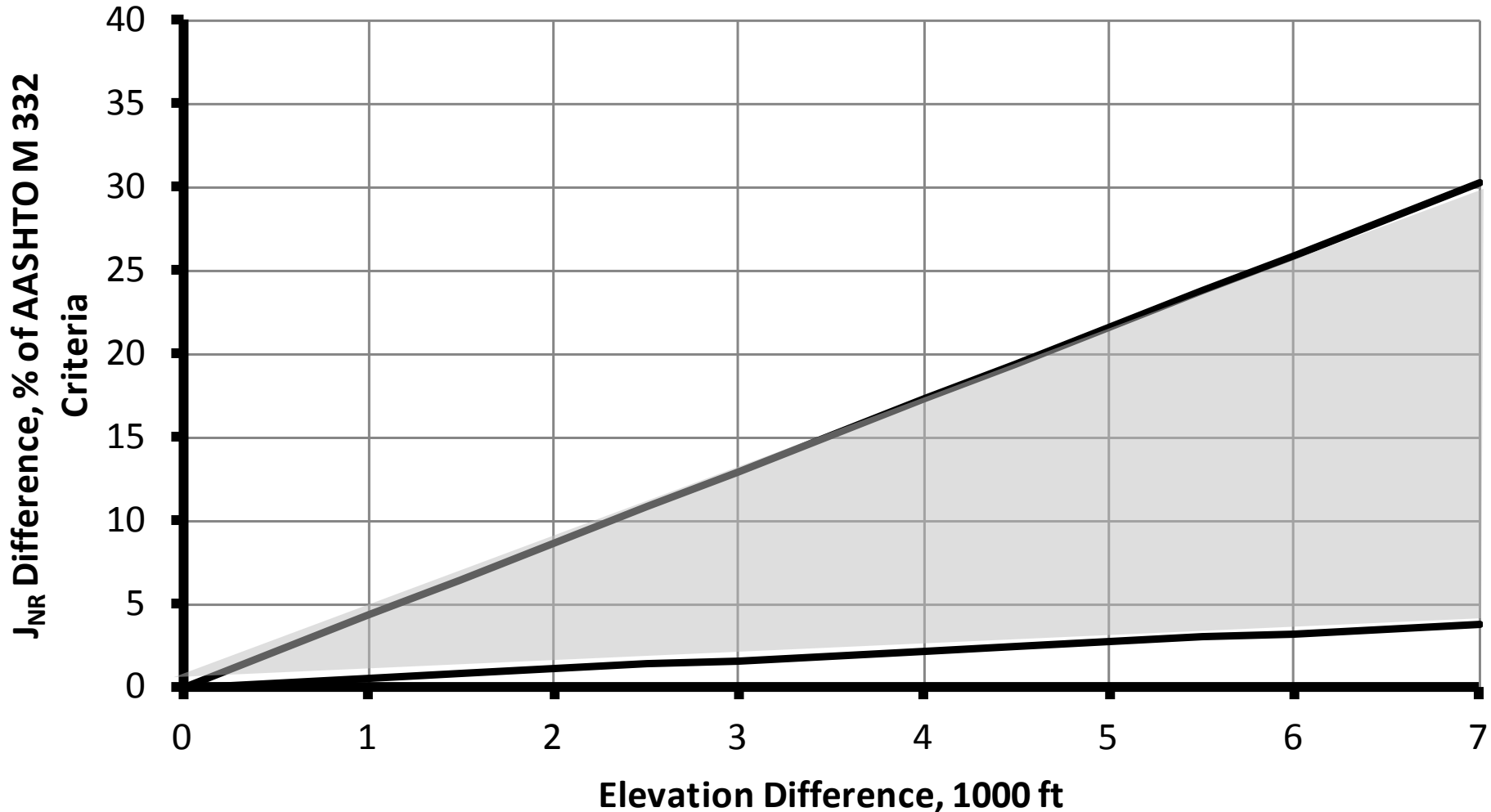
Data Set	Binder	Type*	RTFOT G*/sin δ , kPa/1,000 ft	Aging Index	Mass Change, %/1,000 ft	Jnr, kPa ⁻¹ /1,000 ft	%R, %/ 1,000 ft
WCTG	551	P	-0.0615	-0.0354	-0.0033	0.0333	-0.059
	552	P	-0.0641	-0.0427		0.0432	-0.269
	553	P	-0.0239	-0.0146		0.0394	-0.432
	554	P	-0.0173	-0.0136		0.0677	-0.677
	555	N	-0.1149	-0.0740		0.0927	-0.119
	556	P	-0.0496	-0.0251		0.0027	0.010
	557	P	-0.0914	-0.0442		0.0204	-0.546
	560	P	-0.0477	-0.0271		0.0416	-0.415
	561	P	-0.0477	-0.0379		0.0593	-0.282
	562	P	-0.0701	-0.0609		0.0249	0.720
	563	P	-0.0448	-0.0147		0.0076	-0.413
AASHTO Resource	235/236	N	-0.0613	-0.0374	-0.0059	0.0384	-0.094
	239/240	N	-0.0806	-0.0412		0.0470	-0.032
	241/242	P	-0.0302	-0.0233		0.0002	0.519
	245/246	P	-0.0257	-0.0188		0.0236	-0.300

* N denotes neat binder, P denotes polymer modified binder

Engineering Significance of Elevation Effect: $G^*/\sin\delta$



Engineering Significance of Elevation Effect: J_{nr}

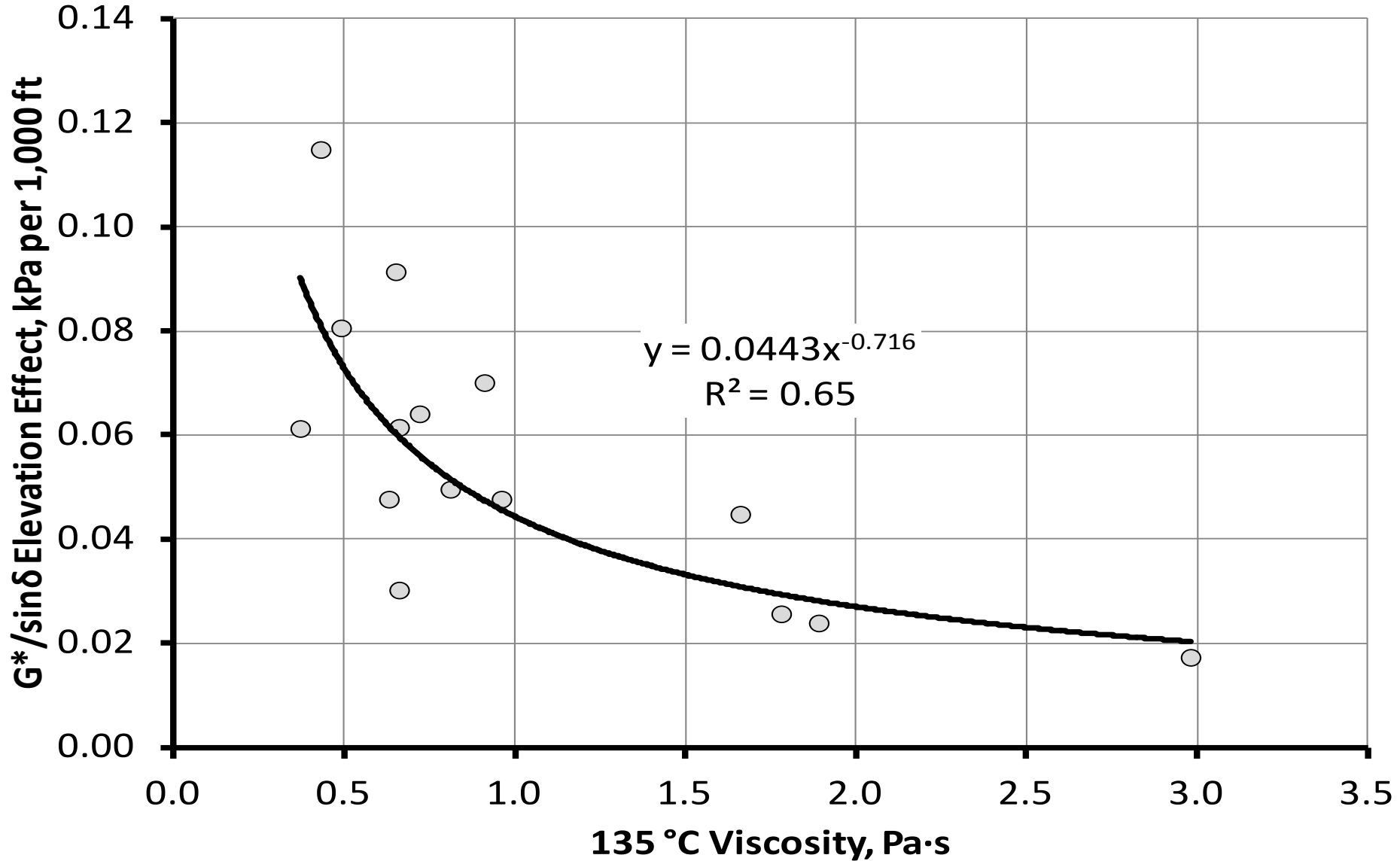


What Are the Options?

- Modify RTFOT to condition at a constant pressure
- Relate elevation effect to other measured binder properties
- Vary RTFOT temperature with elevation
- Vary RTFOT time with elevation



Elevation Effect Prediction

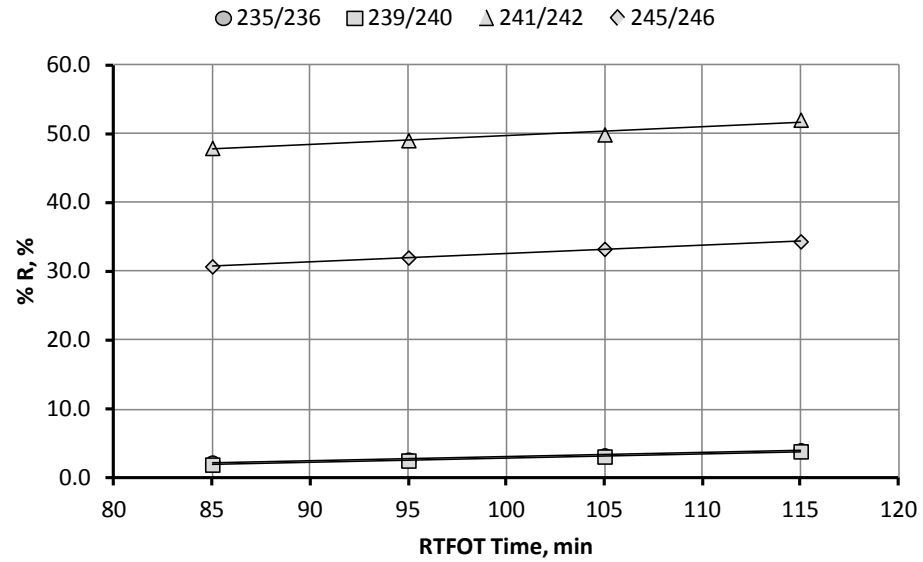
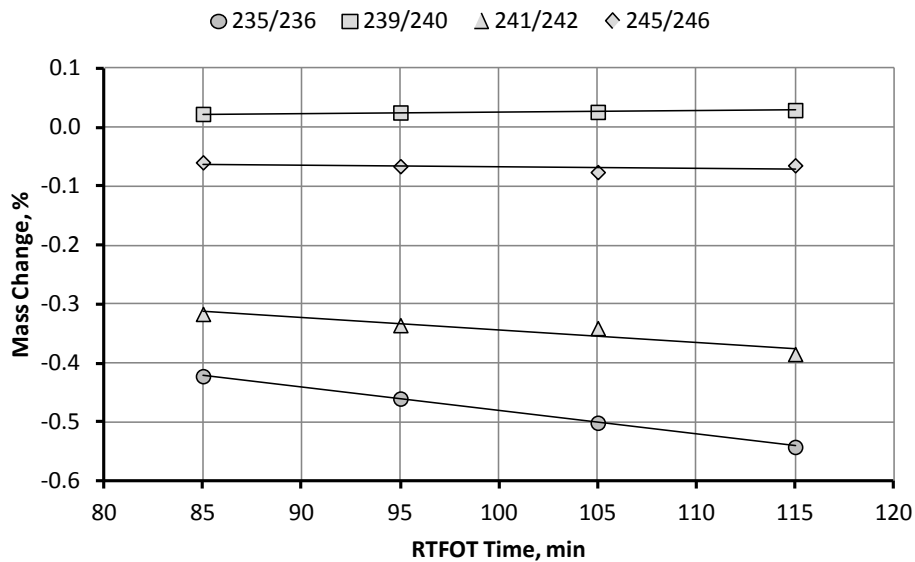
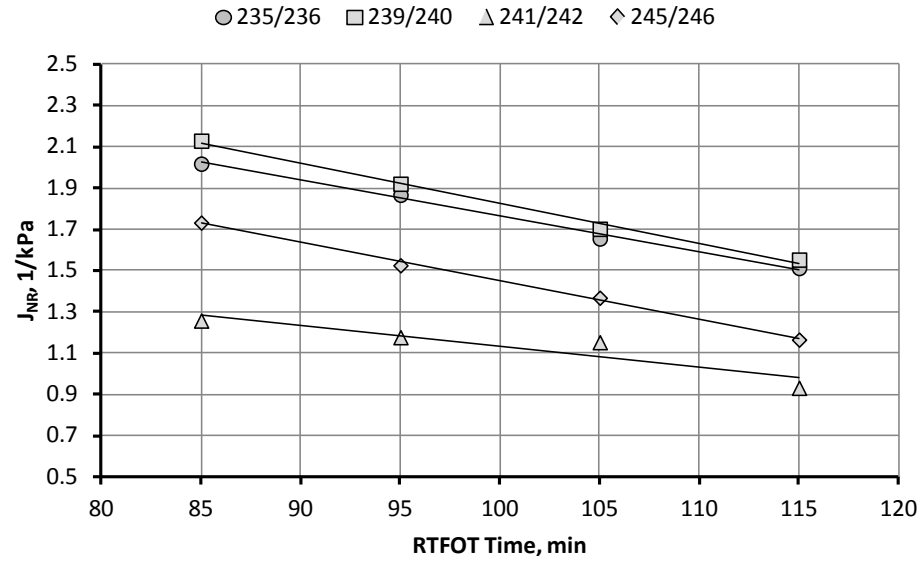
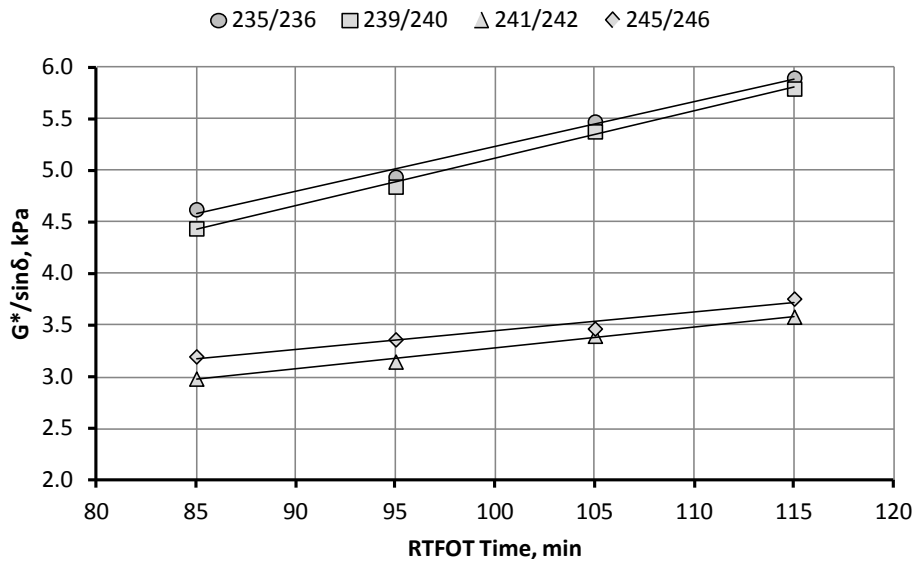


What Are the Options?

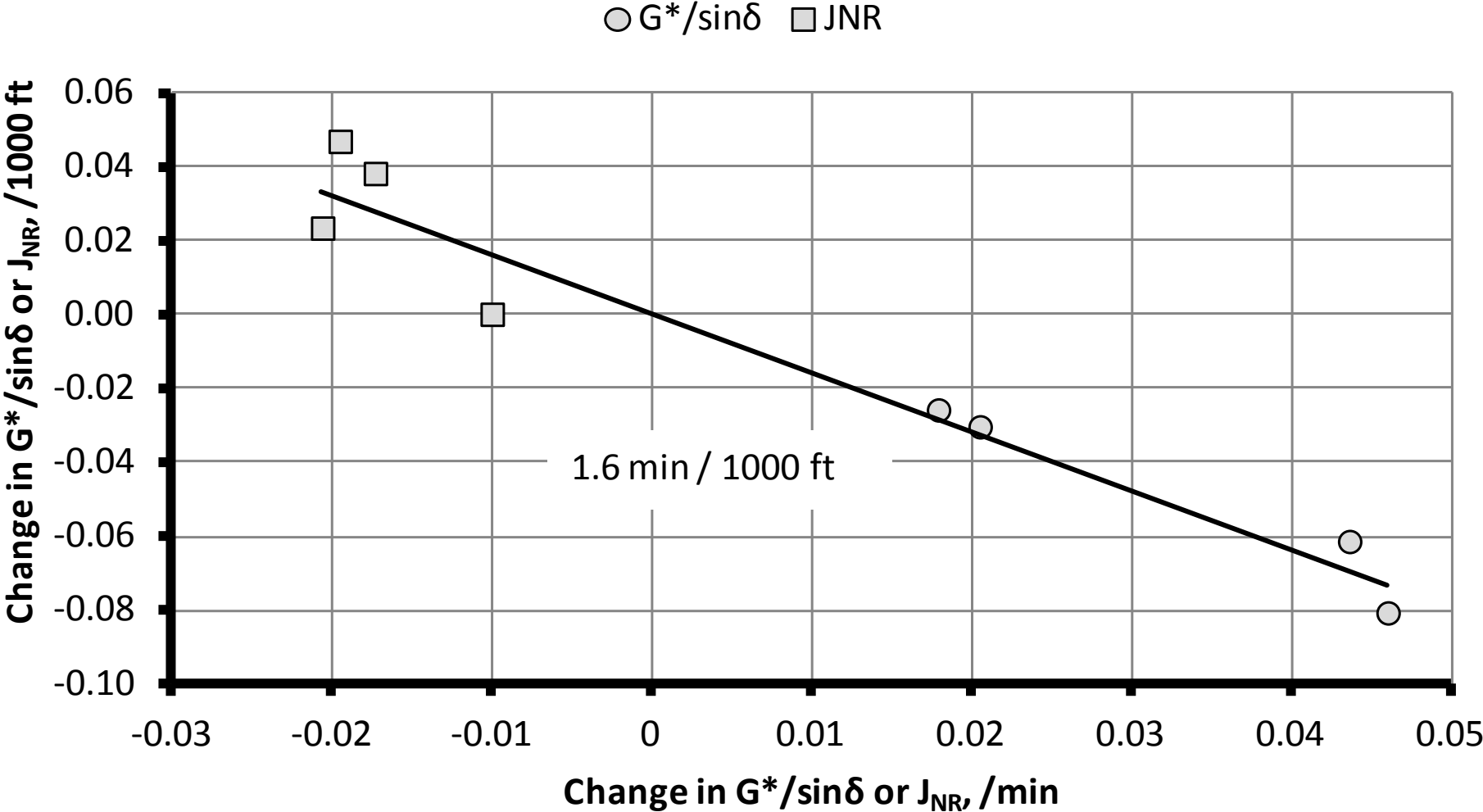
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Effect of Time on RTFOT Residue Properties



Estimate of Additional RTFOT Conditioning Time



Estimate of Additional RTFOT Conditioning Time

Elevation, 1000 ft	Additional RTFOT Conditioning Time, min
0	0
1	2
2	3
3	5
4	6
5	8
6	10
7	11



Next Step

- Complete experimental design to confirm/improve additional time estimate

Item	Description
Number of Laboratories	24, 8 in three elevation range blocks: <ul style="list-style-type: none">• 0 to <2500 ft• 2500 to <5000 ft• ≥ 5000 ft
Number of binders	8 including neat and modified binders
RTFOT conditioning times	2
Responses	AASHTO T 240: mass change AASHTO T 315: $G^*/\sin\delta$ AASHTO T 350: $J_{nr3.2}$, and $R_{3.2}$
Analysis	Regression



Volunteers?

- AMRL Accreditation
- Condition 4 binders
 - 85 minutes
 - 115 minutes
- Measure mass change
- Return conditioned residue
- Estimate 16 man-hours of effort

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