APPENDIX S

SENSITIVITY ANALYSIS OF DESIGNING PROGRAM

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This appendix presents the results of a sensitivity analysis of the predicted scale coefficients, ρ, in different severity levels. The scale coefficient, ρ, is the number of days for reflection cracks to reach 36.8 percent (=1/e) of their total length in the overlaid pavement prior to overlay. In the sensitivity analysis, the overlay is varied between 0.5 inch and 10 inches thickness in six or seven increments. The results of predicted scale coefficients, ρ, for different climate zones and pavement structures is presented. Table S-1 summarizes the number of sections to run the sensitivity analysis in each different pavement structures and climate zones.

Figure S-1 shows sensitivity analysis of ρ_{LMH} for an AC overlay over an AC pavement in a wet-freeze climate zone. The model of this sensitivity analysis includes 25 LTPP (Long Term Pavement Performance) sections. It shows the upper bound and the lower bound of this model. According to the trend of both bounds, the scale coefficients (ρ_{LMH}) become more variable when the overlay thickness increases. When the overlay thicknese is thin, the mean value of ρ_{LMH} is around 1450 days. The upper bound of thin overlay is 1.38 times of the mean value, and the lower bound is 0.62 times the mean value. When overlay thickness increases to 6 inches, the mean value increases to 3200 days, the ratios of upper bound and lower bound to the mean value are 1.87 and 0.13, respectively. A similar trend exists in the same model for ρ_{MH} in Figure S-2. A thin overlay thickness shows a smaller mean value of ρ (= 4000 days), and the ratio of upper bound and lower bound to the mean value are 1.5 and 0.5, respectively. The mean value of the ρ-value increases with the overlay thickness (= 4850 days), and the ratio of upper bound and lower bound to the mean are 1.86 and 0.14, respectively. However, the high severity level (ρ_H) model shows a different trend as in Figure S-3. The trend of the upper bound and lower bound of the ρ_H-values is slightly decreased with the overlay thickness. In addition, the lower bound shows a more significant decrease because of the two outlier sections.

A total of 27 LTPP sections were used in the sensitivity analysis of an AC overlay over a JPC pavement structure in a wet-freeze climate zone. Figures S-4, S-5, and S-6 show the results of ρ_{LMH}, ρ_{MH}, and ρ_H severity levels, respectively. These figures show that the range of ρ-values increases with overlay thickness. The upper bound of the three severity levels shows a direct relationship to overlay thickness, but the lower bound shows an inverse relationship to overlay thickness. Figures S-7, S-8, and S-9 show the results of the sensitivity analyses of an AC overlay over an FC(SC) pavement structure in a wet-freeze climate zone. This model shows the same trend in the ρ-values. The thin overlay pavement has a greater range of ρ-values than the thick overlay pavement, and the scale coefficient, ρ, for each severity level increases with overlay thickness. The sensitivity analyses of an AC overlay over a CRC pavement structure in a wet-freeze climate zone for ρ_{LMH} and ρ_{MH} are shown in Figures S-10 and S-11, respectively. This model shows a smaller range of the ρ-values. In the low+medium+high severity level (in Figure S-10), the upper bound shows no change with different thicknesses, and the lower bound shows a steeply decreasing trend because of the one outlier section. The medium+high severity level in Figure S-11 shows no significant ρ-value range with changing overlay thickness. Figures S-12 and S-13 present an AC overlay over AC pavement structures in a wet-no freeze climate zone for ρ_{LMH} and ρ_{MH} severity levels. This model shows that the ρ-value range increases with overlay thickness. Increasing the overlay thickness to 6-inches, the mean value of ρ_{LMH} increases to around 3500 days, and 5500 days for ρ_{MH}. The sensitivity analysis of ρ_{LMH} for an AC overlay over an FC(SC) pavement structure in a wet-no freeze climate zone (Figure S-14) exhibits the same pattern as the previous AC overlay over an AC pavement structure model, but the ρ-value range in a thick overlay is much smaller relative to the mean value (4250 days). These are 0.82 times the mean value for lower bound and 1.18 times for the upper bound.

Table S-1. Summary of sensitivity analytic sections in different climate zones and pavement structures.

Climate Zones	Pavement Structures Overlay/Existing Layer	ρ_{LMH}	ρ_{MH}	ρ_{H}
Wet-Freeze	AC/AC	25	25	25
	AC/JPC (JRC)	27	27	27
	AC/FC(SC)	8	8	8
	AC/CRC	6	6	N/A
	AC/Reinforcing/PCC	24	24	N/A
Wet-No Freeze	AC/AC	16	16	N/A
	AC/FC(SC)	6	N/A	N/A
	AC/Reinforcing/PCC	7	N/A	N/A
Dry-Freeze	AC/AC	9	9	9
	AC/Reinforcing/AC	10	N/A	N/A
Dry-No Freeze	AC/AC	13	13	13

Figures S-15, S-16, and S-17 show a sensitivity analysis for an AC overlay over an AC pavement structure in a dry-freeze climate zone for three different severity levels (ρ_{LMH}, ρ_{MH}, and ρ_{H}). All three severity levels show a larger ρ-value range in the thin overlay pavement , and the range decreases with overlay thickness. The three severity levels for an AC overlay over an AC pavement structure in a dry-no freeze climate zone appear in Figures S-18, S-19, and S-20. This model presents a clear pattern for the scale coefficient (ρ), and both the upper bound and lower bound increase with overlay thickness. Furthermore, the ρ-value band width at each severity level is close to a constant.

The sensitivity analyses of an AC overlay with a reinforcing layer are presented in Figure S-21 to S-24. The summary of these results is that the range of the scale coefficient, ρ, increases with overlay thickness. Figures S-21 and S-22 show the sensitivity analysis of ρ_{LMH} and ρ_{MH} for an AC overlay over a reinforcing layer over a PCC pavement structure in New York City (wet-freeze climate zone). The upper bound for both ρ_{LMH} and ρ_{MH} severity levels show a direct relationsip with overlay thickness, but the lower bound of ρ_{LMH} shows an inverse relationship with overlay thickness. The data for the same pavement structure in Waco, Texas (wet-no freeze climate zone) for ρ_{LMH} is presented in Figure S-23. The range of ρ-values increases with overlay thickness in this model and the wide band is caused by one outlier section. Figure S-24 shows a sensitivity analysis of ρ_{LMH} for an AC overlay over a reinforcing layer over an AC pavement structure in a dry-freeze climate zone (Amarillo, Texas). The same ρ-value range patterns exist in this case as well. The outlier sections are the reason for the larger ρ-value ranges with the larger overlay thickness.

Most of the models show less variation in a thin overlay layer, and the ρ-value range increases with overlay thickness. Two models show an inverse ρ-value range pattern which are the AC overlay over an FC(SC) in a wet-freeze climate zone and an AC overlay over an AC pavement in a dry-freeze climate zone. In addition, only one model shows no significant variance in ρ-values with overlay thickness, namely Figure S-11.

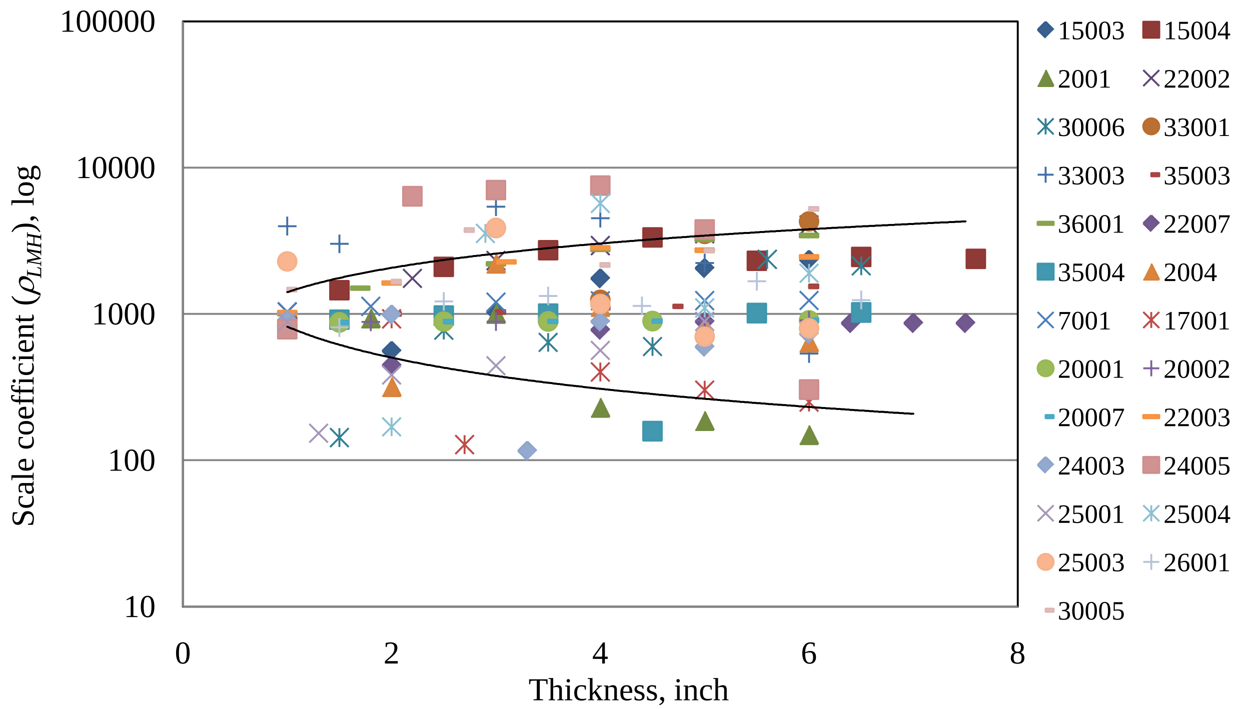

Figure S-1. Sensitivity analysis of ρ_{LMH} for AC over AC pavement structure in a Wet-Freeze climate zone.

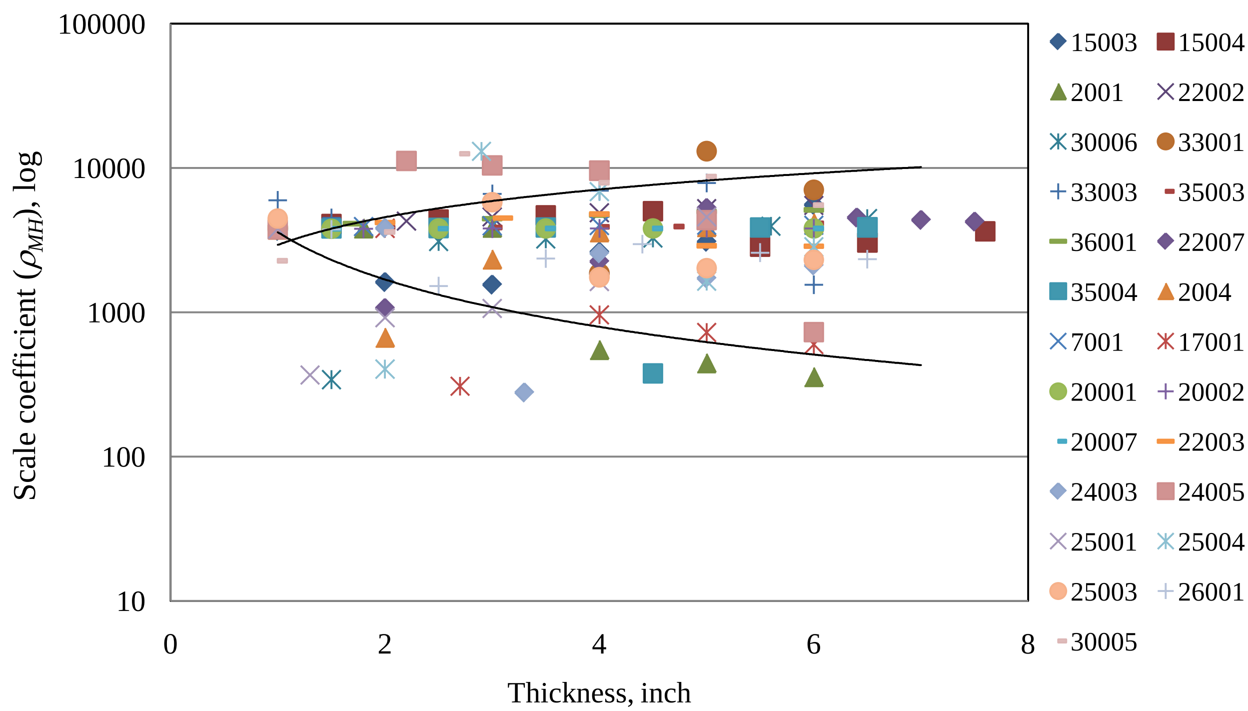

Figure S-2. Sensitivity analysis of ρ_{MH} for AC over AC pavement structure in a Wet-Freeze climate zone.

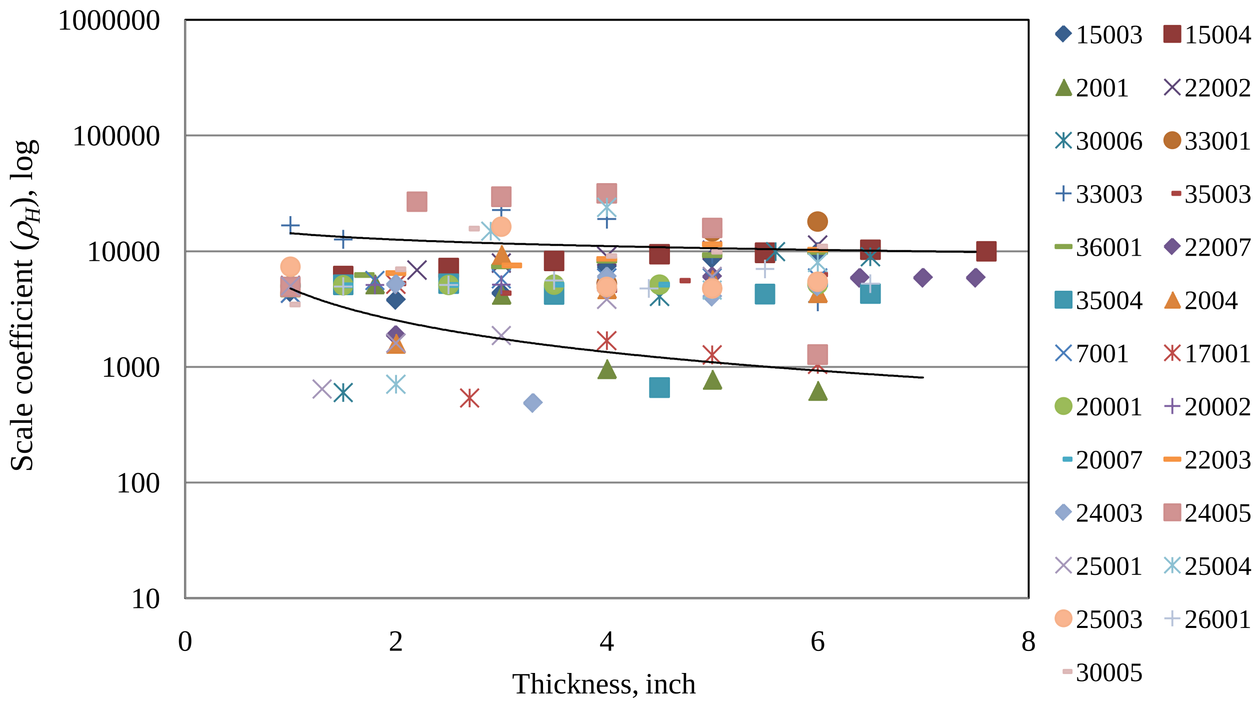

Figure S-3. Sensitivity analysis of ρ_H for AC over AC pavement structure in a Wet-Freeze climate zone.

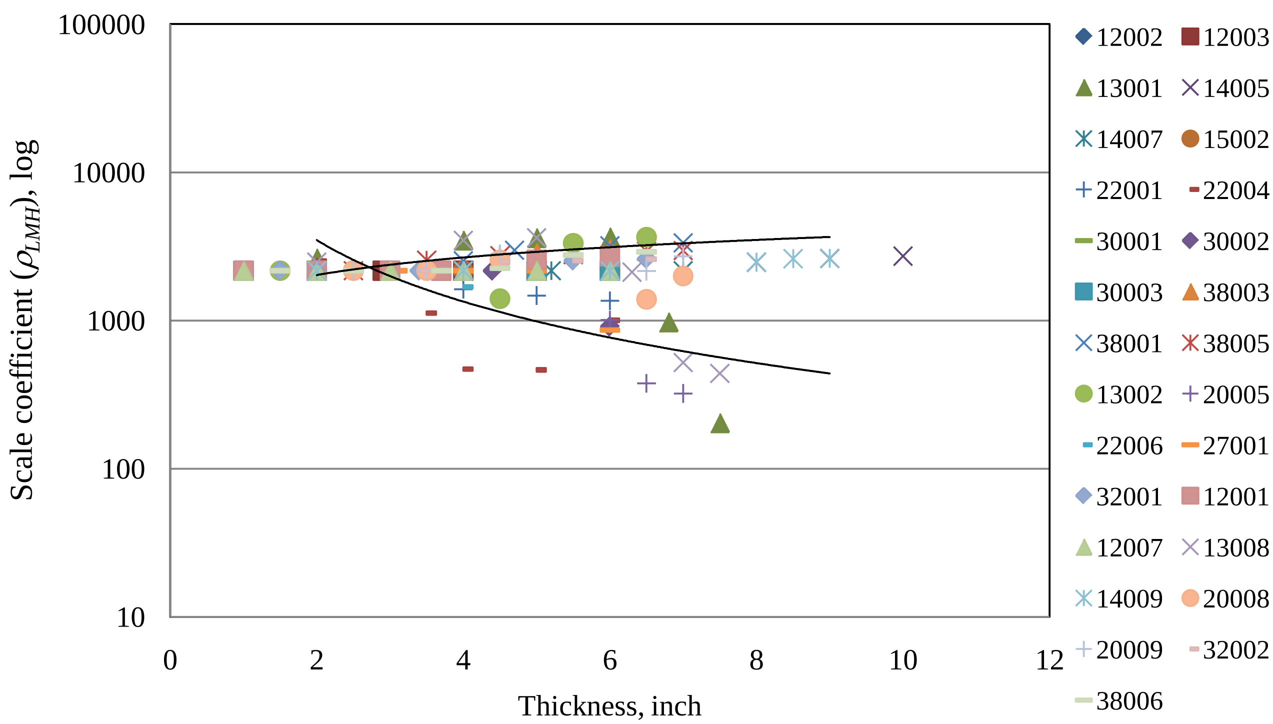

Figure S-4. Sensitivity analysis of ρ_{LMH} for AC over JPC pavement structure in a Wet-Freeze climate zone.

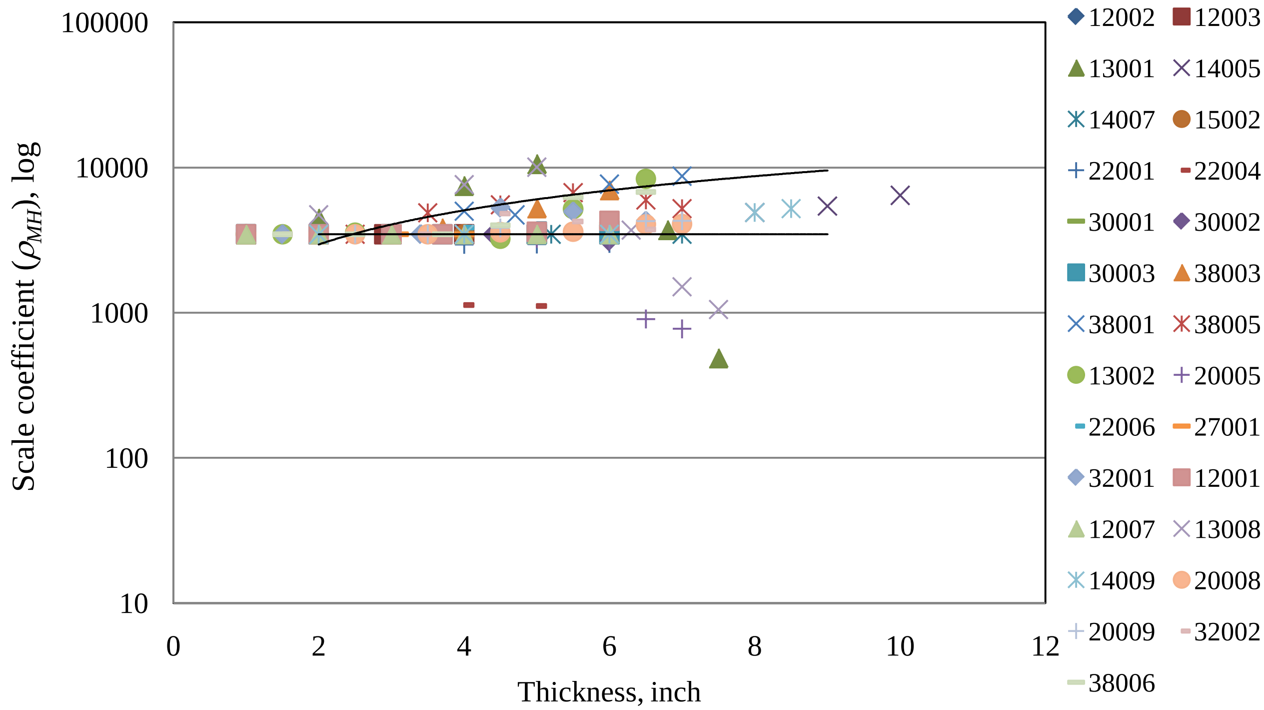

Figure S-5. Sensitivity analysis of ρ_{MH} for AC over JPC pavement structure in a Wet-Freeze climate zone.

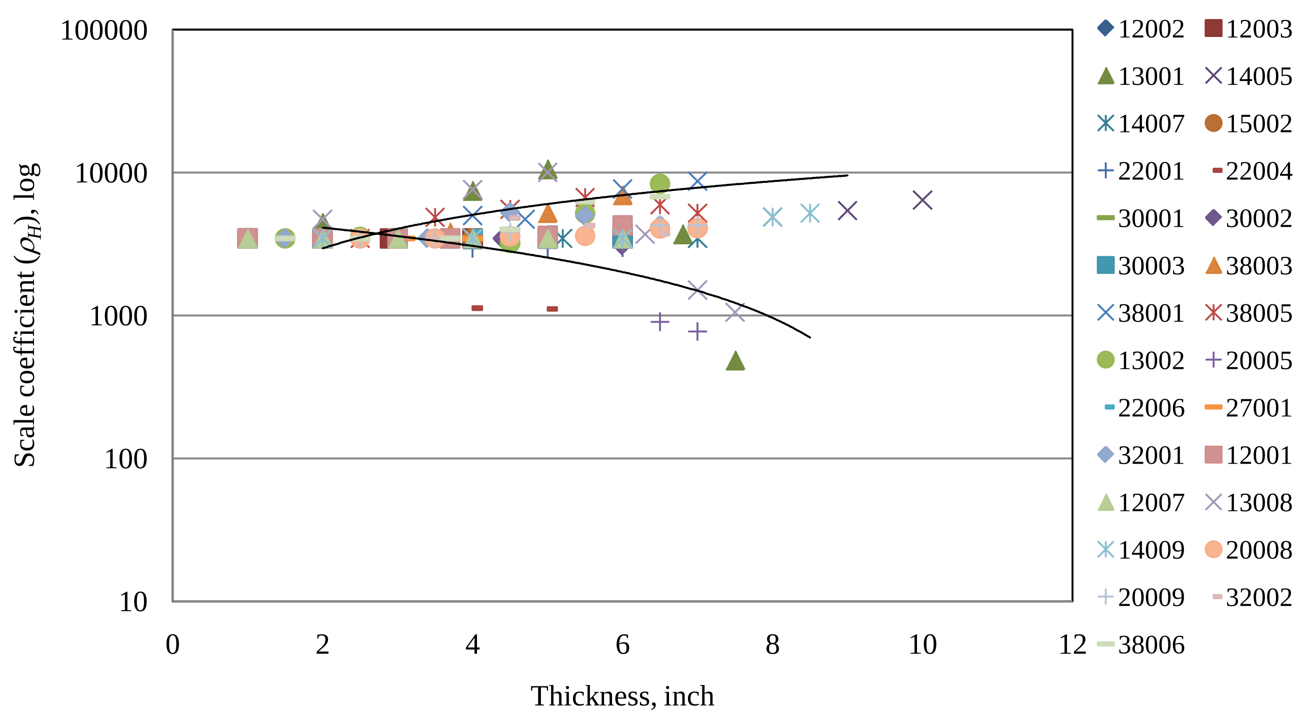

Figure S-6. Sensitivity analysis of ρ_H for AC over JPC pavement structure in a Wet-Freeze climate zone.

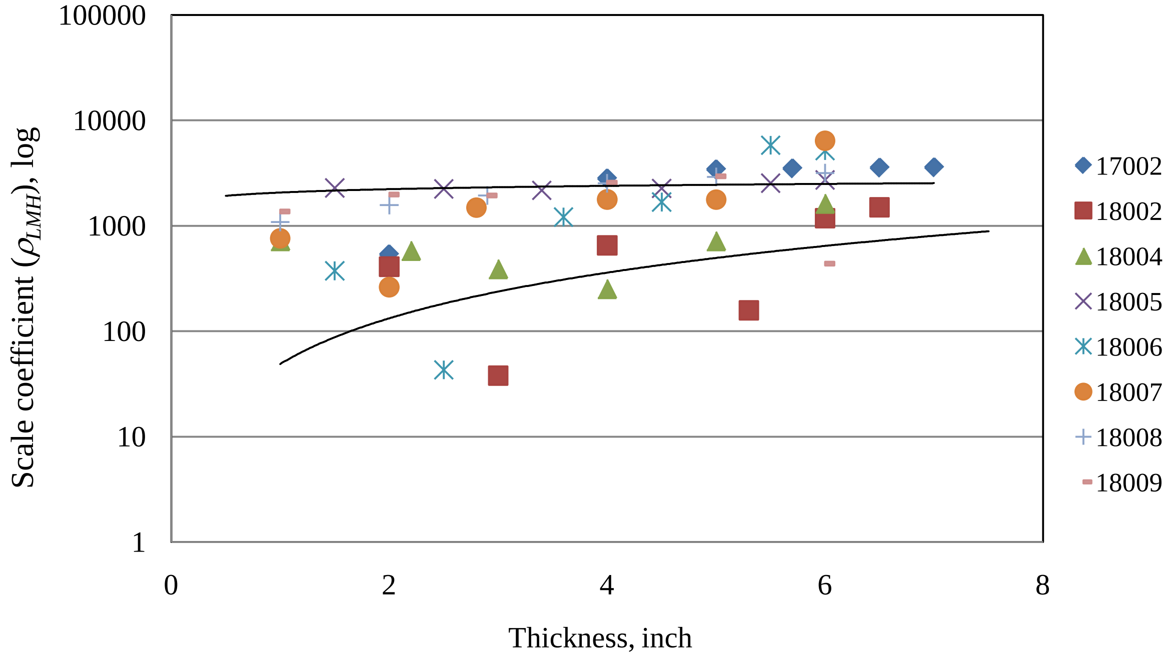

Figure S-7. Sensitivity analysis of ρ_{LMH} for AC over FC (SC) pavement structure in a Wet-Freeze climate zone.

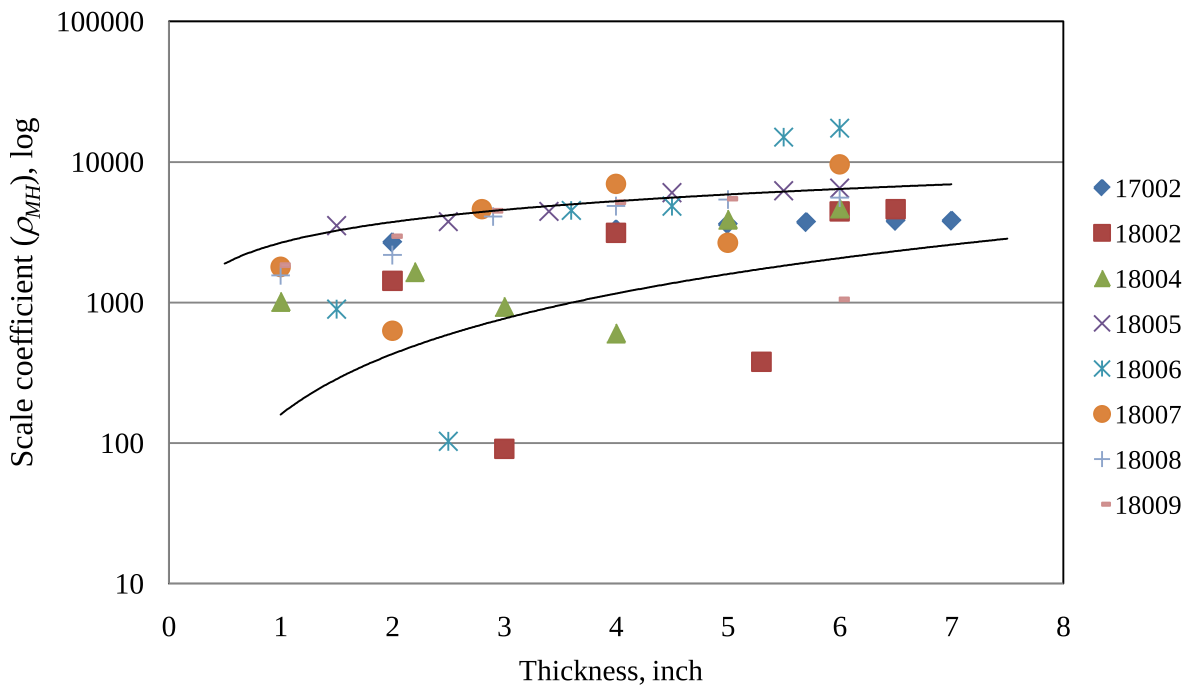

Figure S-8. Sensitivity analysis of ρ_{MH} for AC over FC (SC) pavement structure in a Wet-Freeze climate zone.

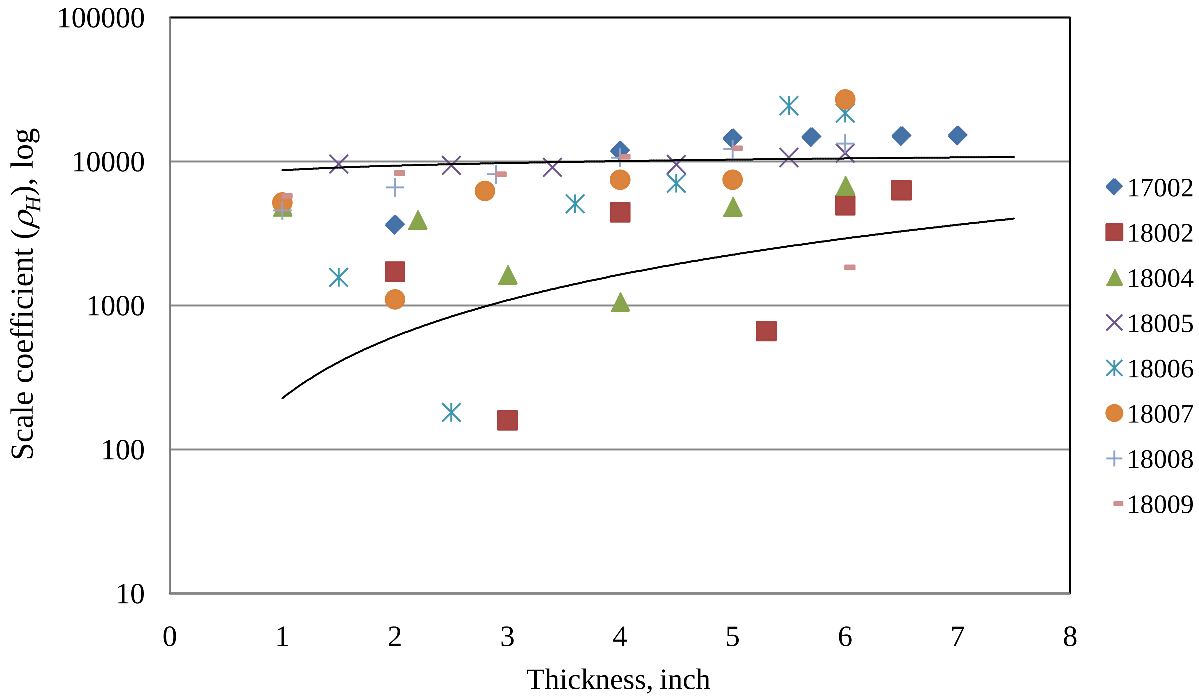

Figure S-9. Sensitivity analysis of ρ_H for AC over FC (SC) pavement structure in a Wet-Freeze climate zone.

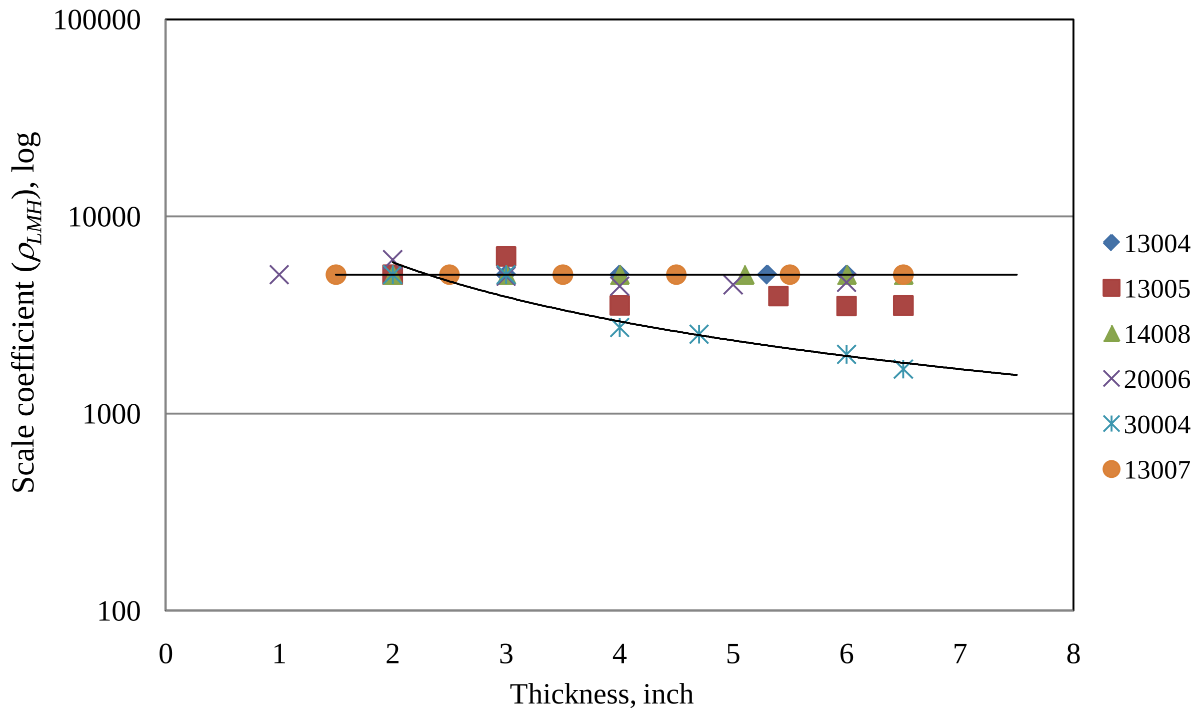

Figure S-10. Sensitivity analysis of ρ_{LMH} for AC over CRC pavement structure in a Wet-Freeze climate zone.

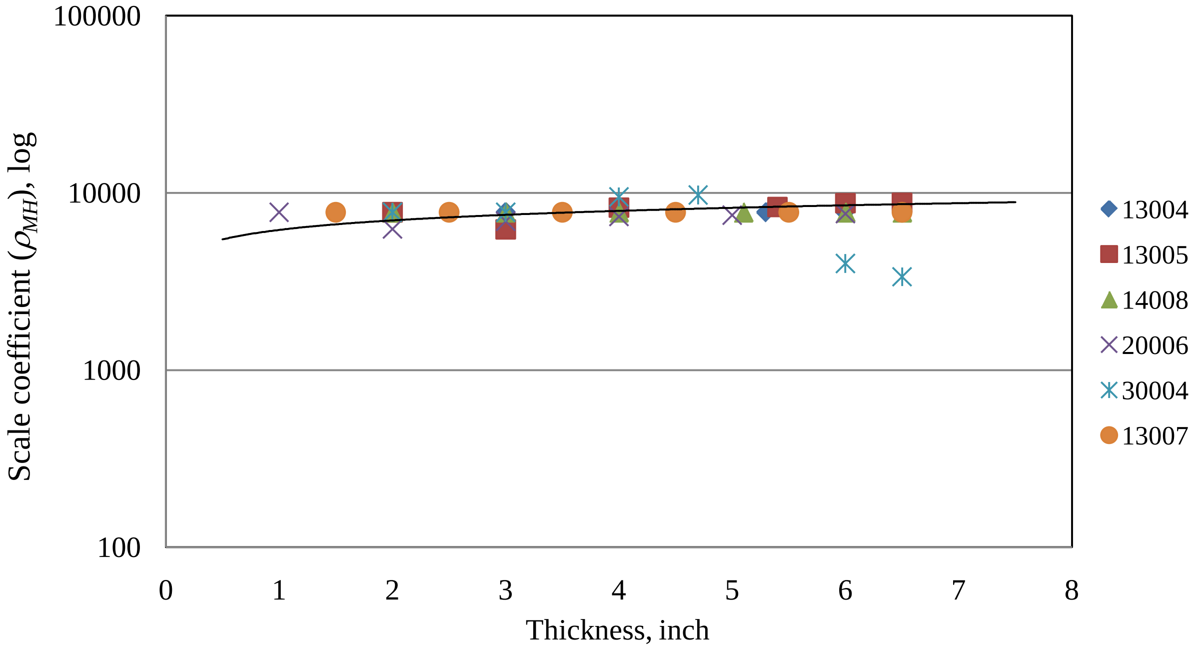

Figure S-11. Sensitivity analysis of ρ_{MH} for AC over CRC pavement structure in a Wet-Freeze climate zone.

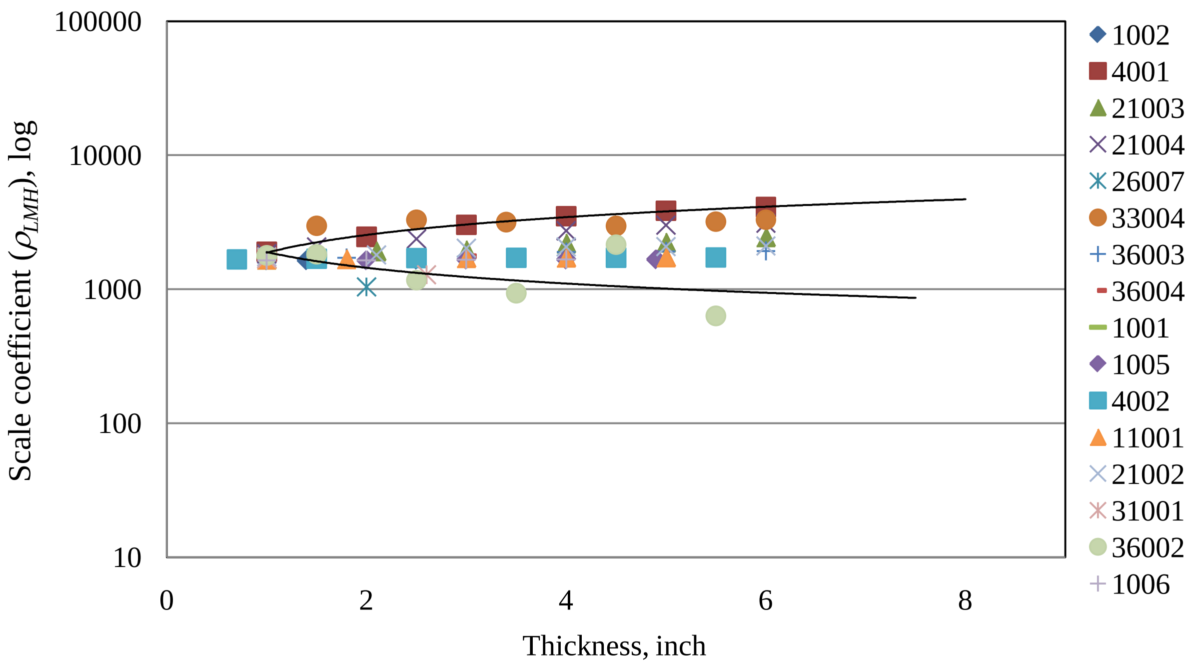

Figure S-12. Sensitivity analysis of ρ_{LMH} for AC over AC pavement structure in a Wet-No Freeze climate zone.

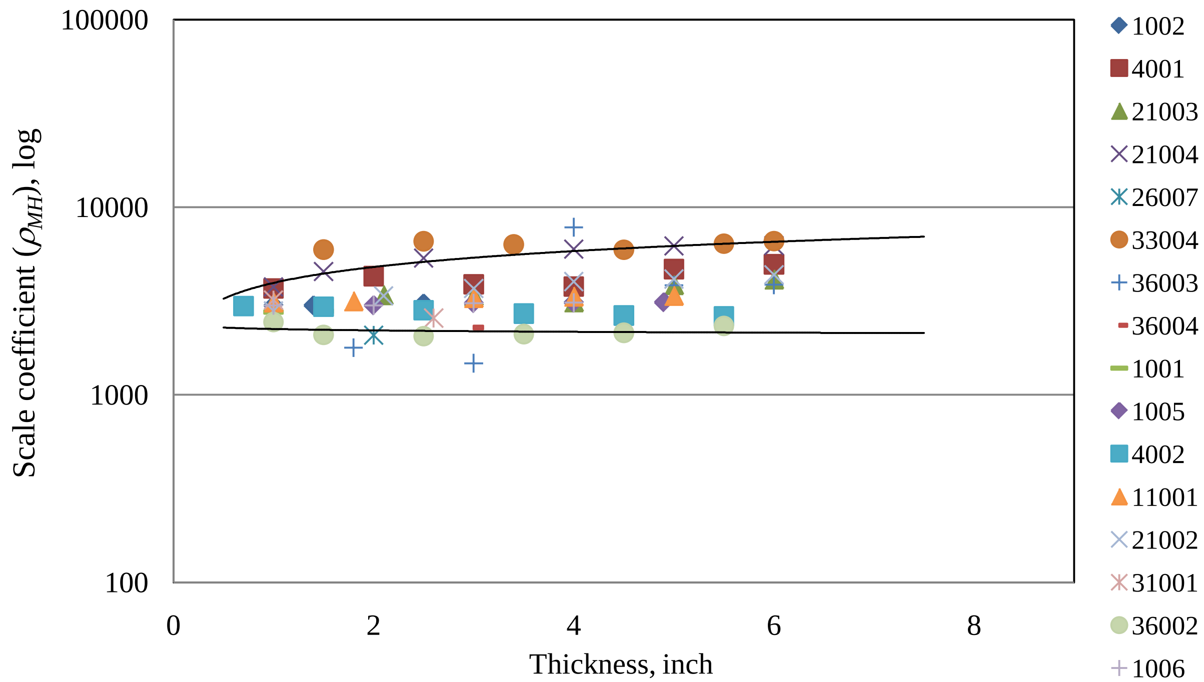

Figure S-13. Sensitivity analysis of ρ_{MH} for AC over AC pavement structure in a Wet-No Freeze climate zone.

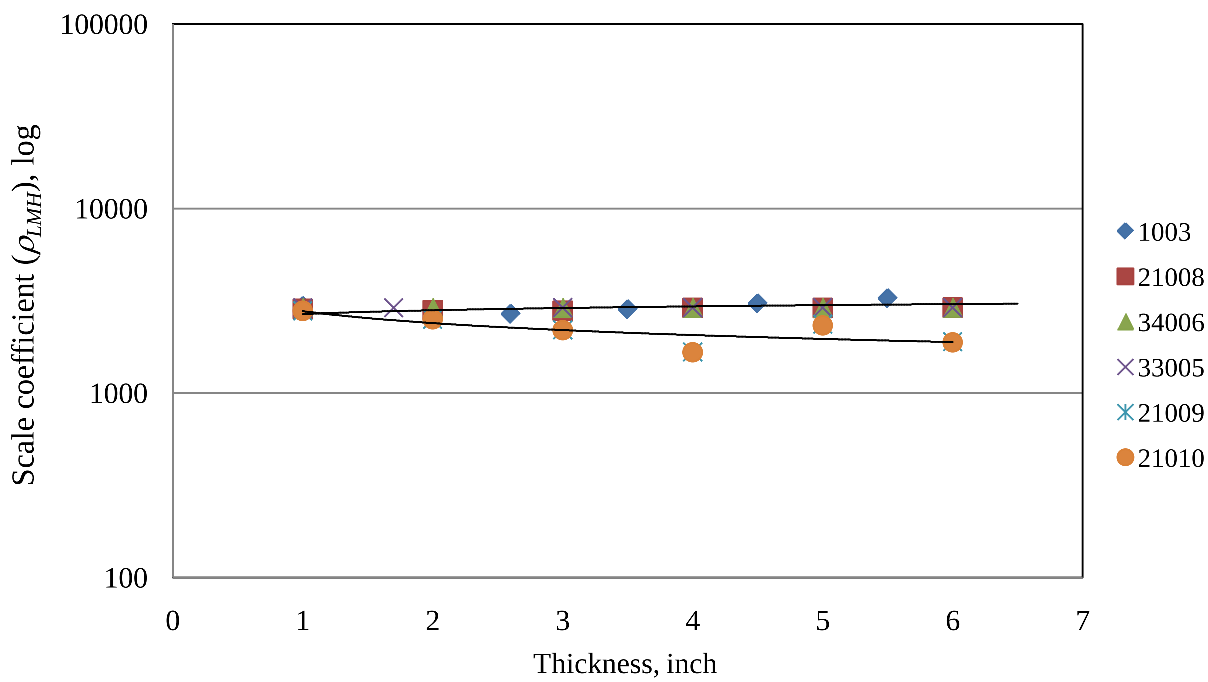

Figure S-14. Sensitivity analysis of ρ_{LMH} for AC over FC (SC) pavement structure in a Wet-No Freeze climate zone.

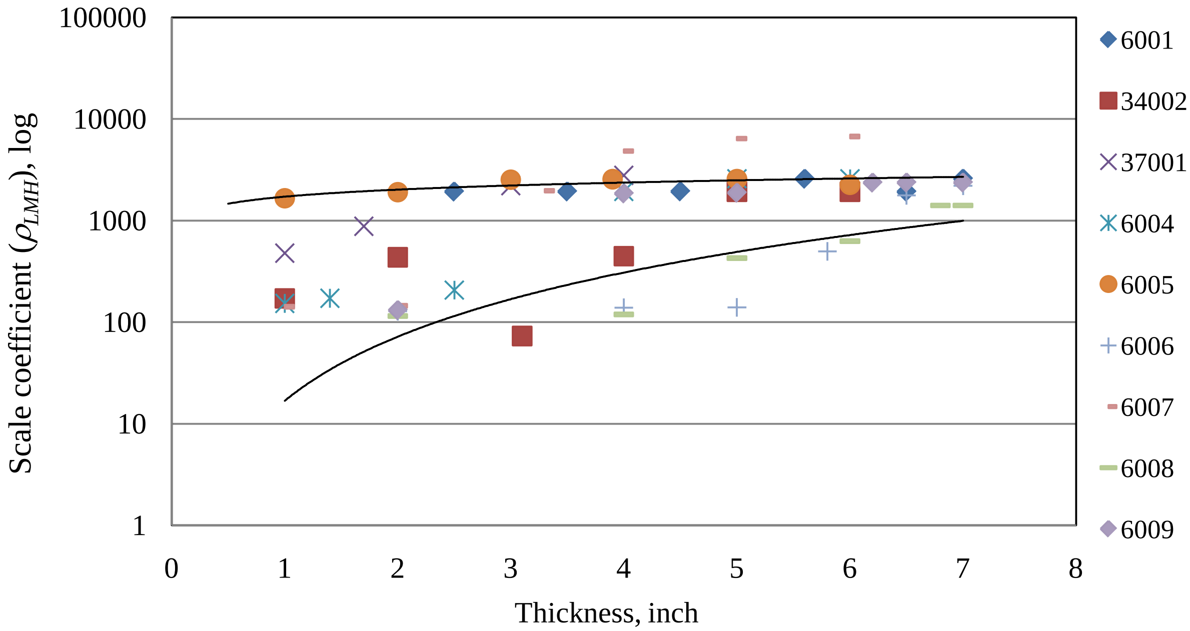

Figure S-15. Sensitivity analysis of ρ_{LMH} for AC over AC pavement structure in a Dry-Freeze climate zone.

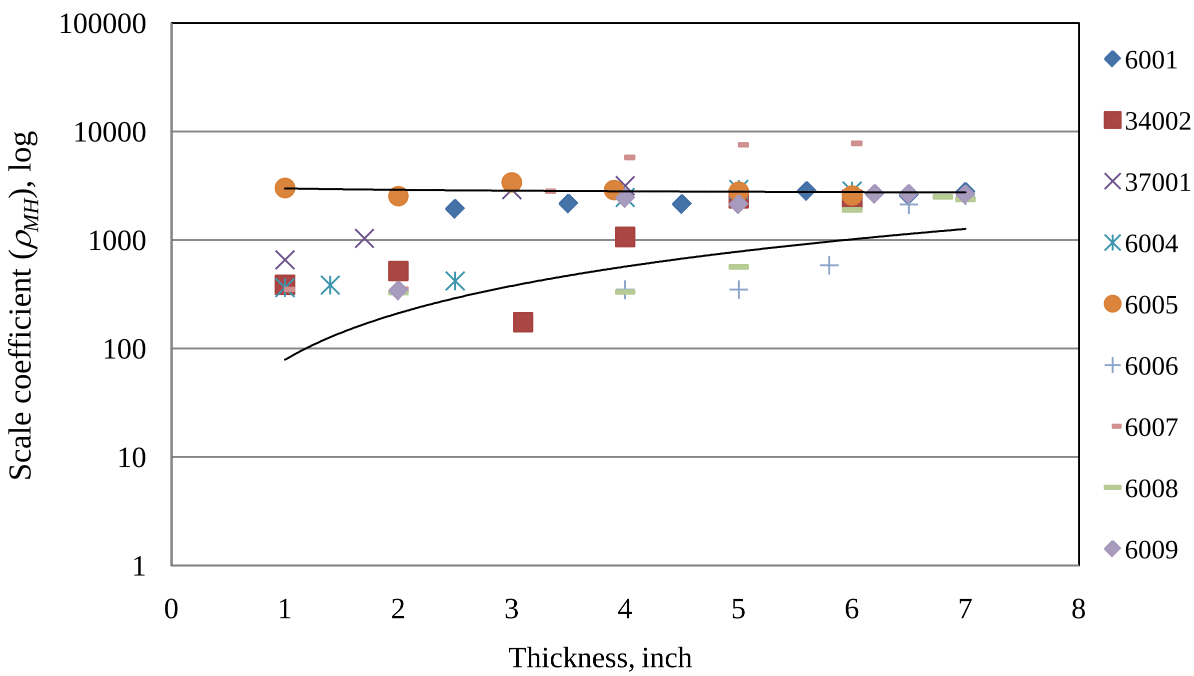

Figure S-16. Sensitivity analysis of ρ_{MH} for AC over AC pavement structure in a Dry-Freeze climate zone.

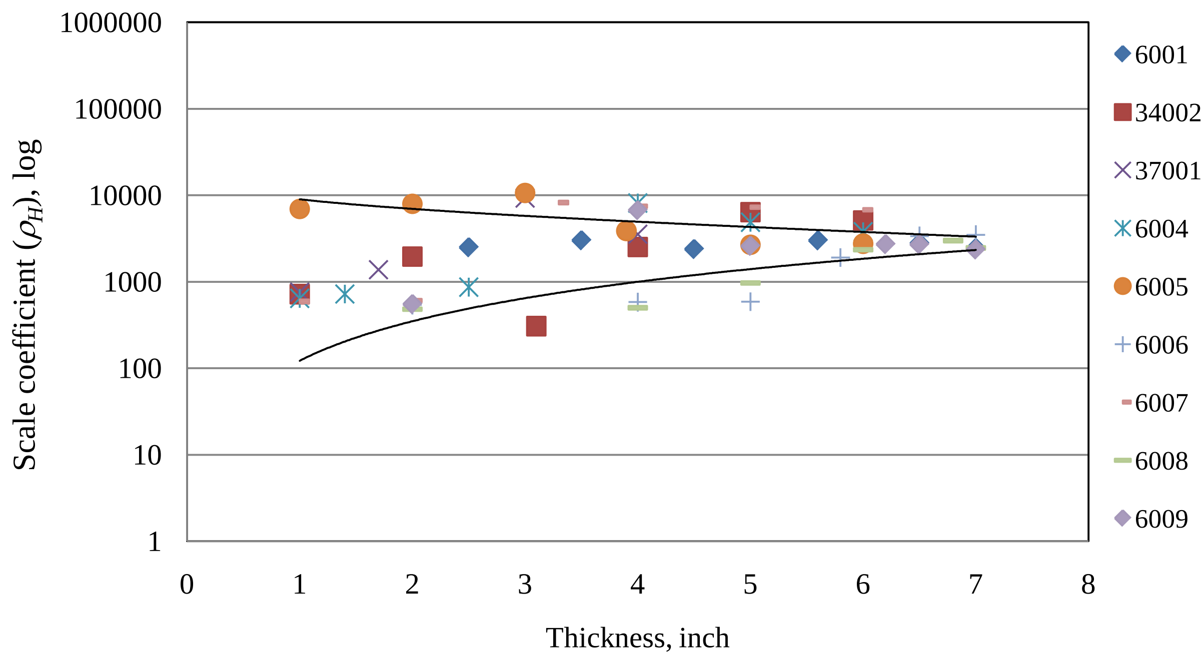

Figure S-17. Sensitivity analysis of ρ_H for AC over AC pavement structure in a Dry-Freeze climate zone.

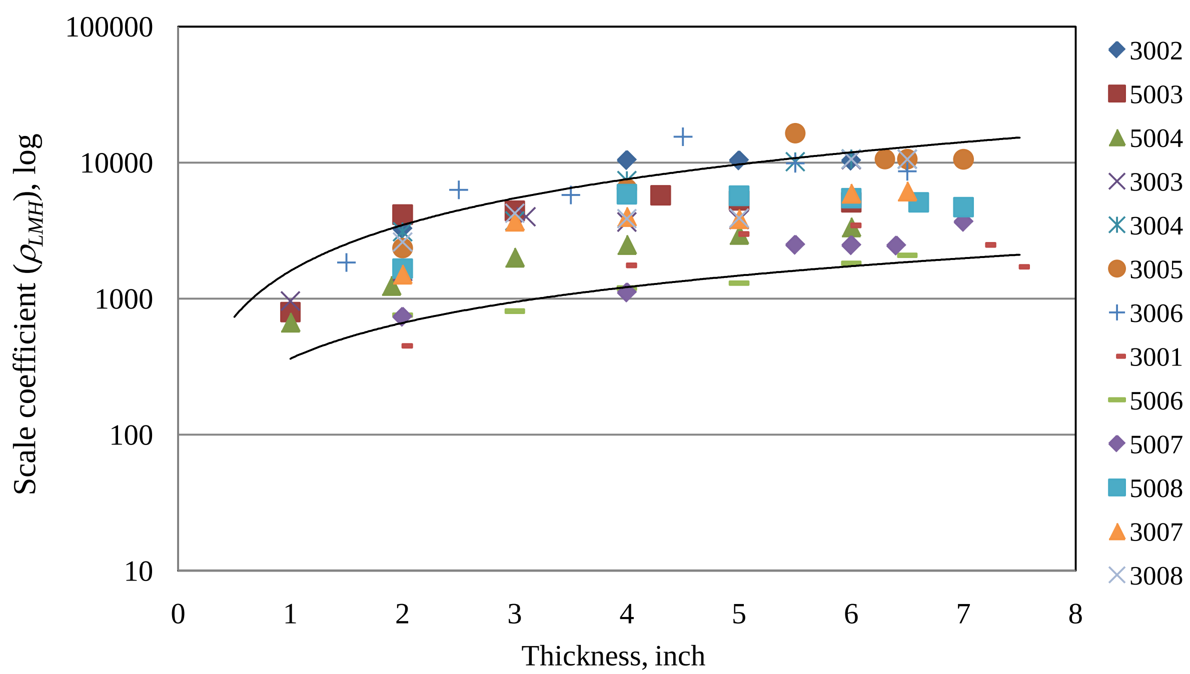

Figure S-18. Sensitivity analysis of ρ_{LMH} for AC over AC pavement structure in a Dry-No Freeze climate zone.

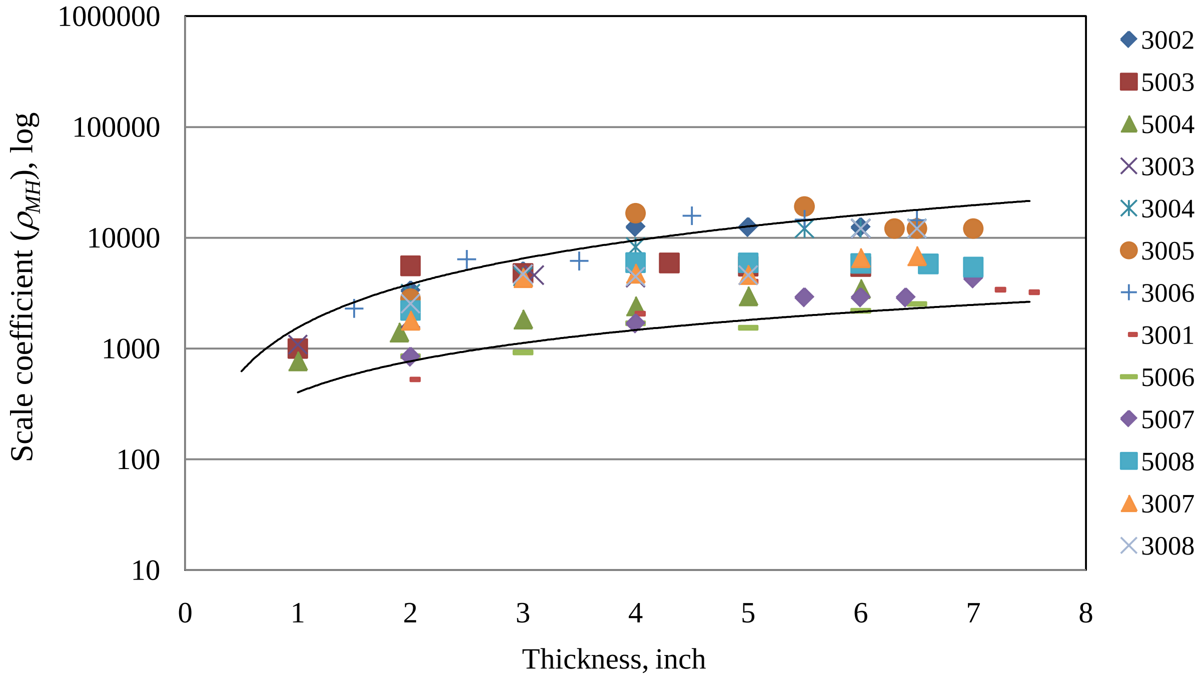

Figure S-19. Sensitivity analysis of ρ_{MH} for AC over AC pavement structure in a Dry-No Freeze climate zone.

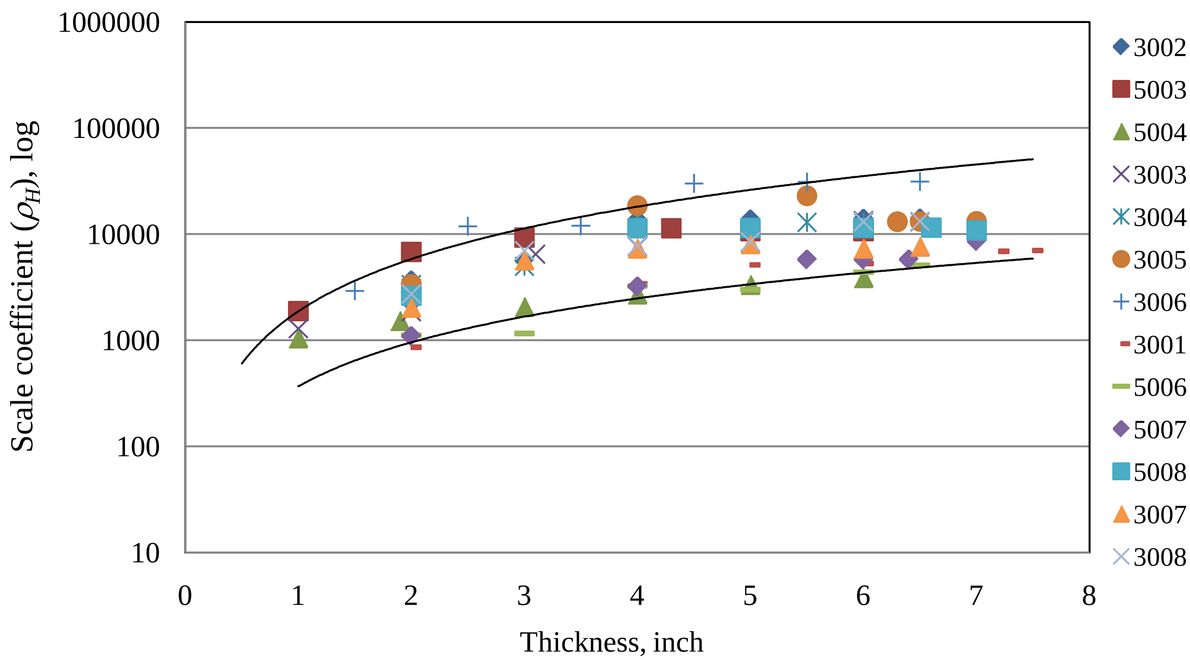

Figure S-20. Sensitivity analysis of ρ_{H} for AC over AC pavement structure in a Dry-No Freeze climate zone.

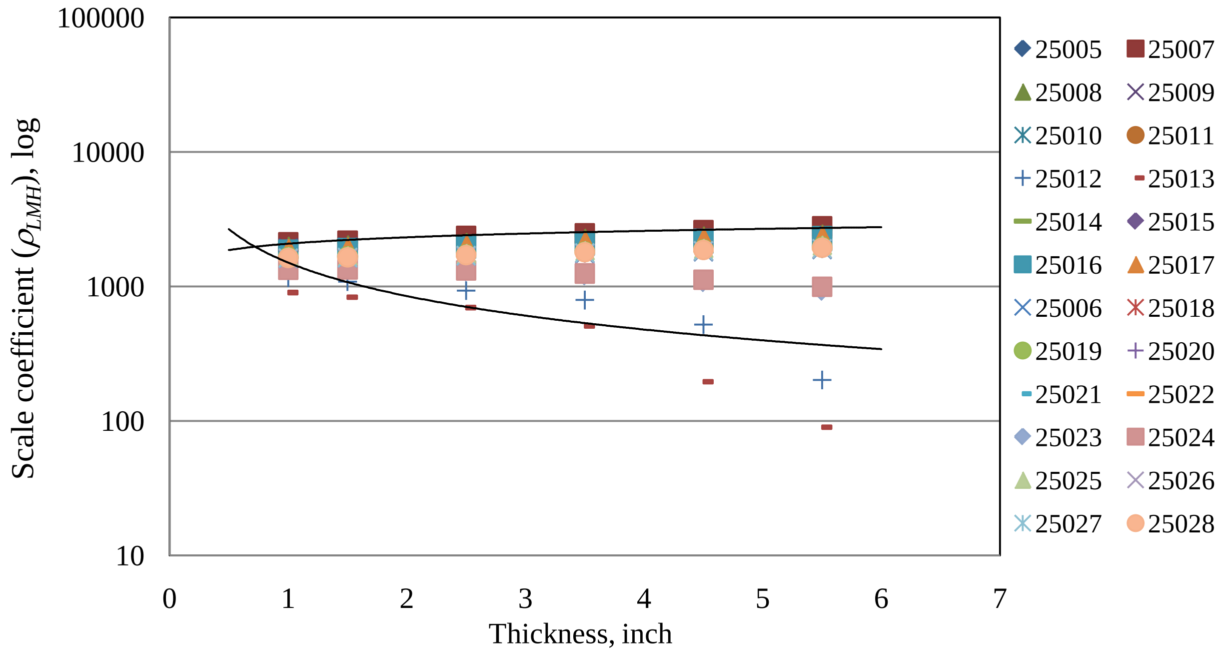

Figure S-21. Sensitivity analysis of ρ_{LMH} for AC over Reinforcing over PCC pavement structure in a Wet-Freeze climate zone.

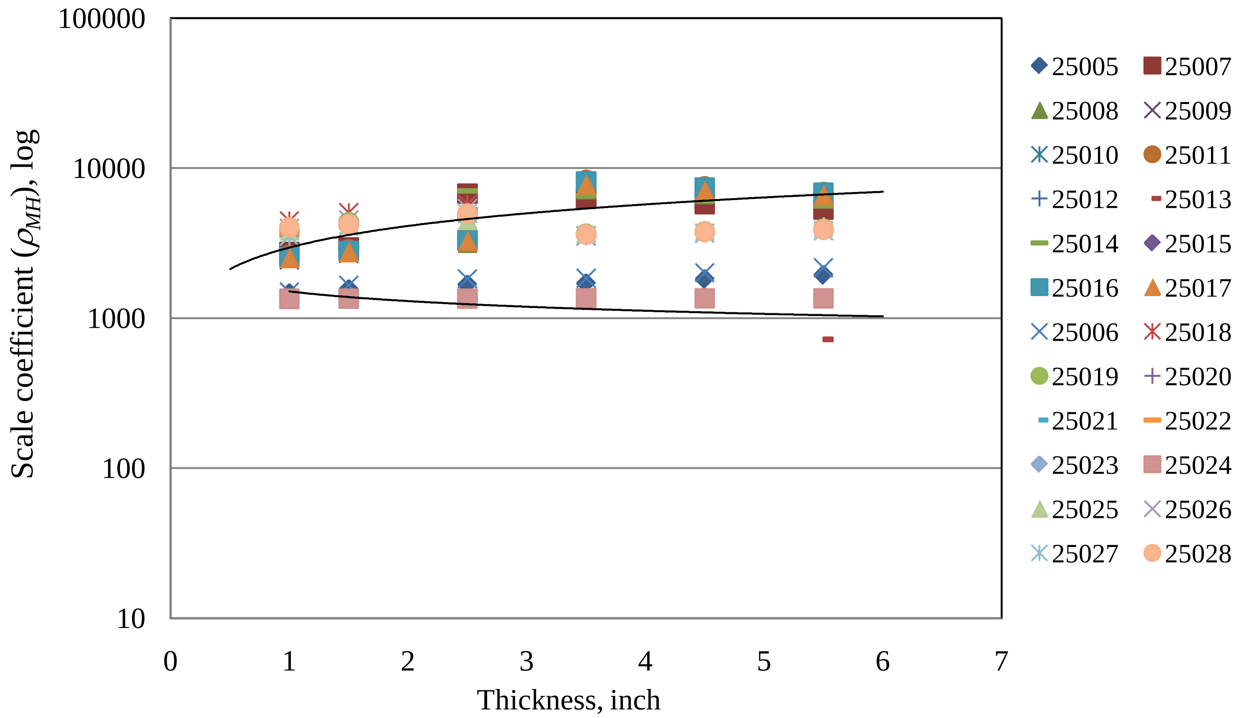

Figure S-22. Sensitivity analysis of ρ_{MH} for AC over Reinforcing over PCC pavement structure in a Wet-Freeze climate zone.

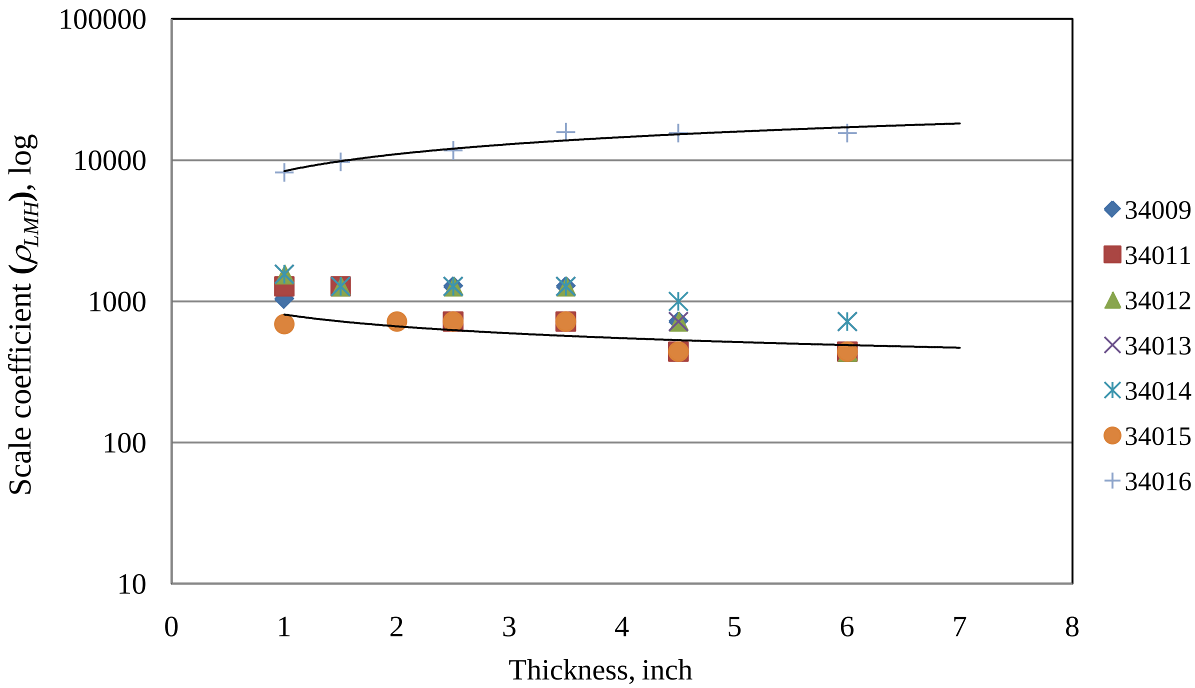

Figure S-23. Sensitivity analysis of ρ_{LMH} for AC over Reinforcing over PCC pavement structure in a Wet-No Freeze climate zone.

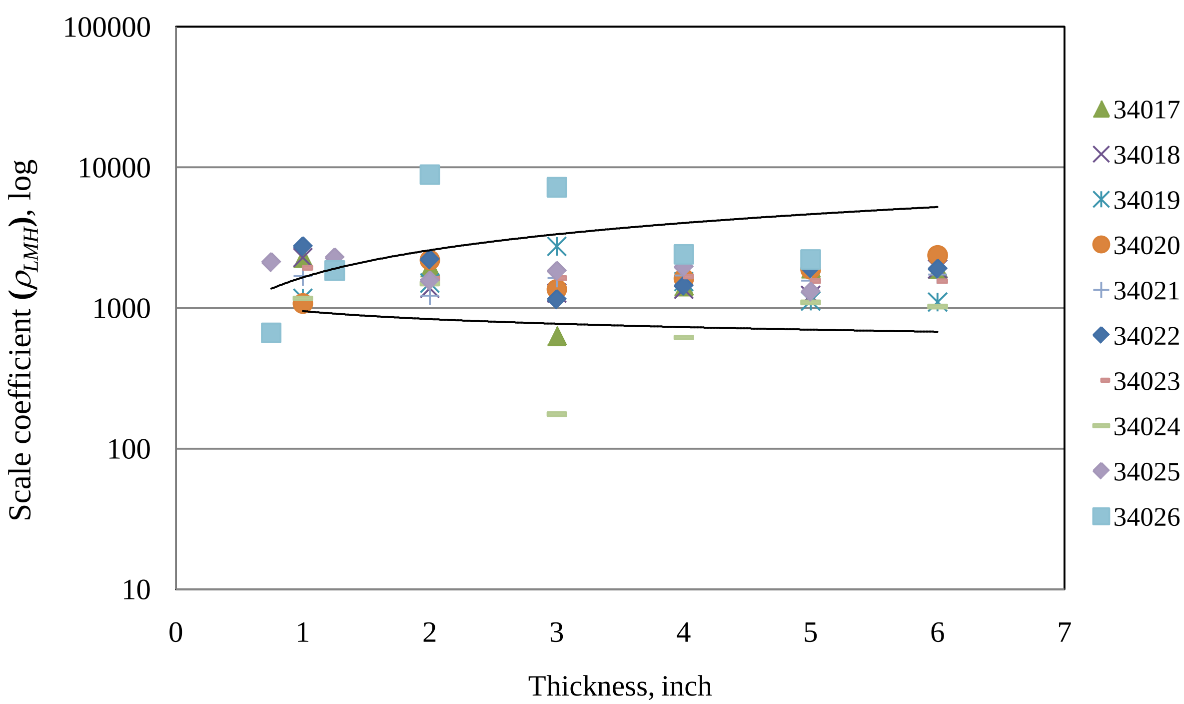

Figure S-24. Sensitivity analysis of ρ_{LMH} for AC over Reinforcing over AC pavement structure in a Dry-Freeze climate zone.