# HMA Mixtures Containing Recycled Asphalt Shingles (RAS): Low Temperature and Fatigue Performance of Plant-Produced Mixtures

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## ABSTRACT

In the paving industry, there is increased interest in using recycled materials like Recycled Asphalt Shingles (RAS) and Reclaimed Asphalt Pavements (RAP) due to the valuable asphalt binder contained within them. The major concern with using these materials is that the binder contained within is highly aged which could lead to reduced mixture durability. Therefore, a method is needed to quantify the extent that the aged binders from these materials blend with virgin binder when producing mixtures in order to better understand their effects on mixture performance.

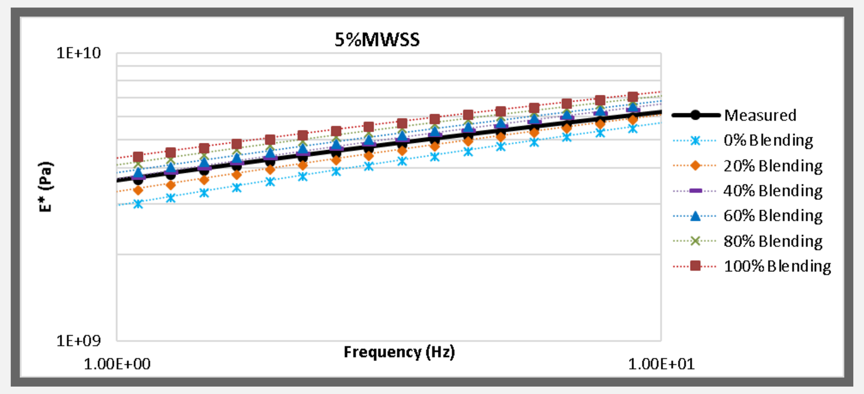
In this study, a new approach to quantify the amount of blending that occurs between aged RAS and RAP binders and a virgin binder was developed. Asphalt binders were extracted and recovered from RAS and RAP stockpiles, blended with a PG64-28 virgin binder in varying proportions, and their master curves were constructed at 20ºC. Asphalt mixtures containing different proportions of the same RAS and RAP stockpiles were then designed and the mixture dynamic moduli were measured to construct mixture master curves at 20ºC.

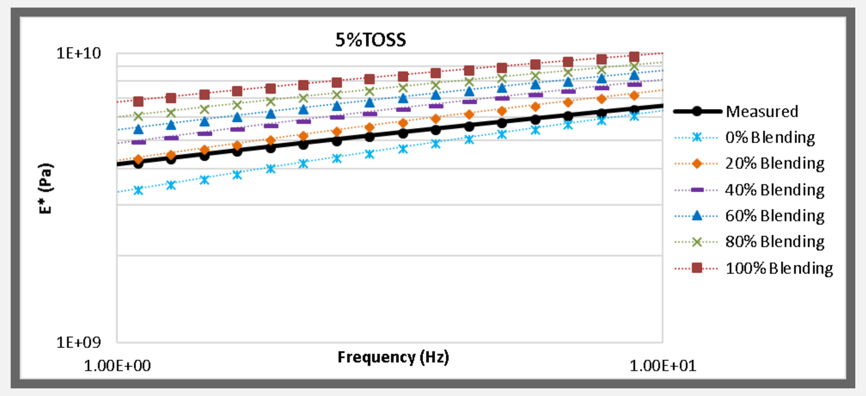
The binder master curves for each blending proportion were then substituted into a locally calibrated Hirsch model to predict the mixture master curves. Comparing measured and predicted mixture master curves suggested that the aged binder from RAS and RAP blends with the virgin binder less than 40% and 60%, respectively. Cracking tests were also conducted to validate the proposed degrees of blending from a mixture mechanical performance point of view.

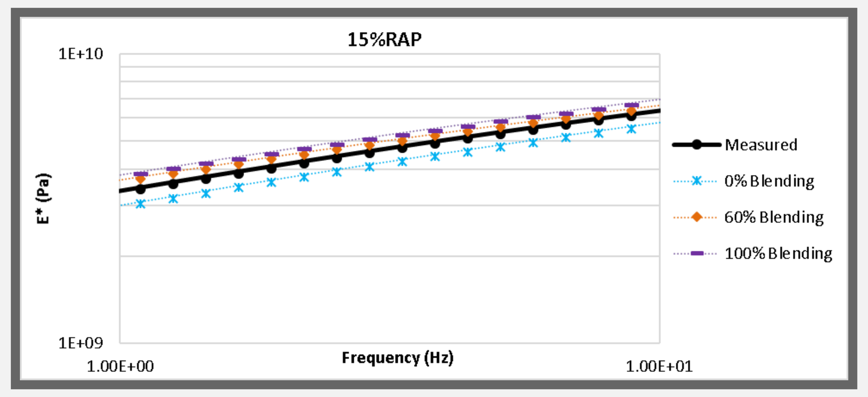

## Degree of Blending

The results derived from substituting binder dynamic modulus (G*) into the Hirsch model to estimate E* are shown along with the E* values measured from the AMPT device.

Experimentally measured master curve of the 5%MWSS and 5%TOSS is plotted along with the predicted master curves for various degrees of blending. It was estimated that between 20% to 40% of binder from 5%MWSS was activated in the mixture, whereas less than 20% was activated for 5%TOSS. Activation of RAP binder was estimated at less than 60% for the 15%RAP mixture.



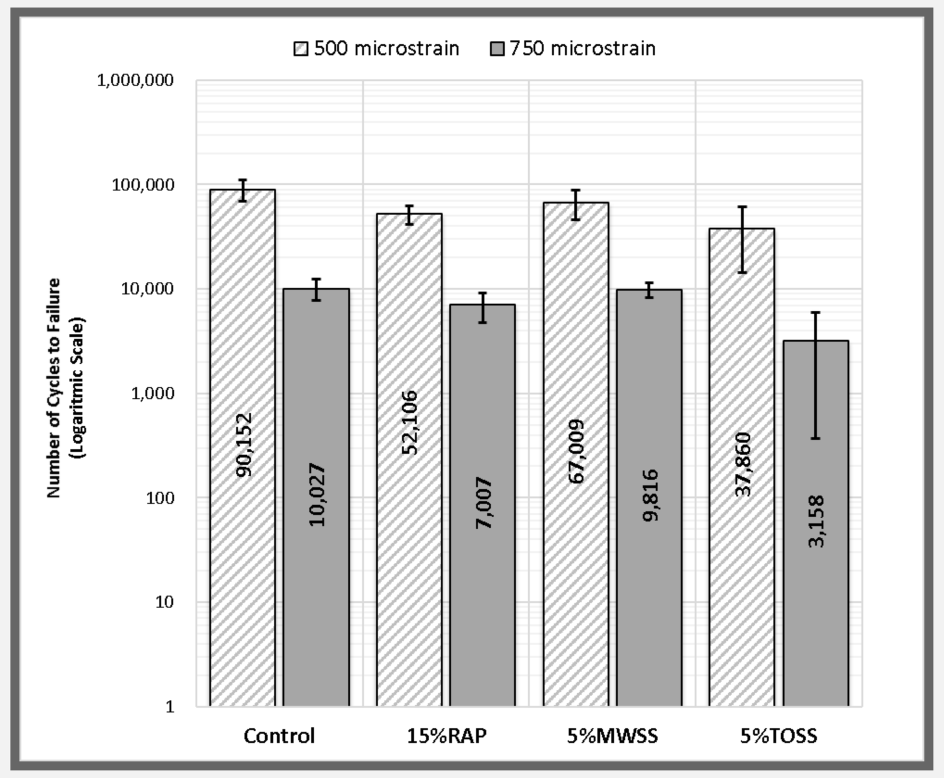



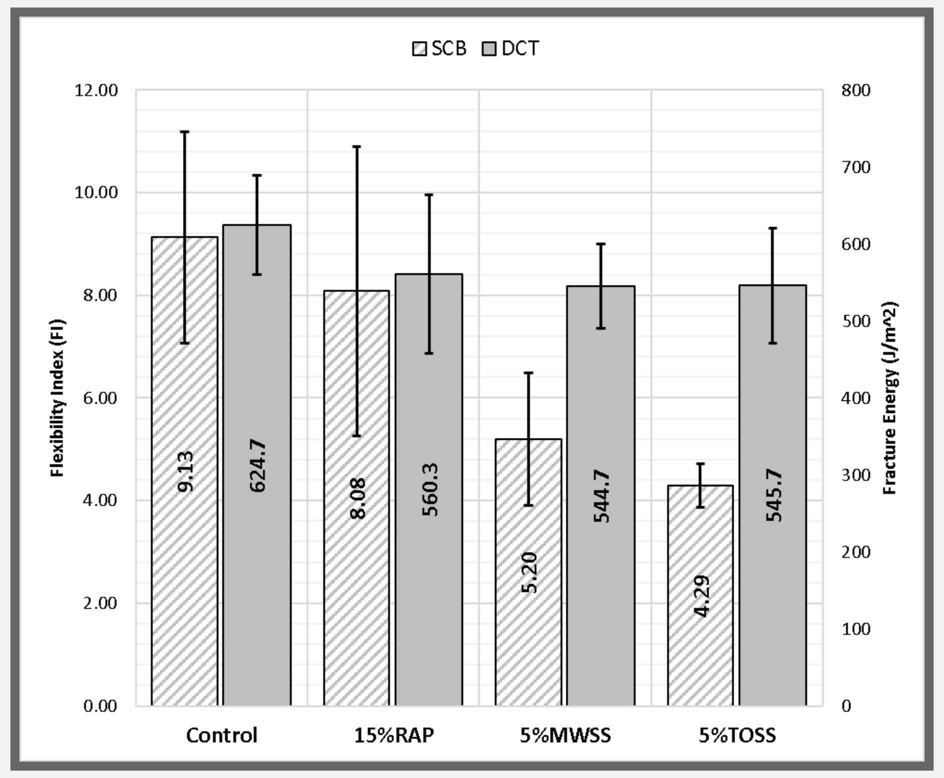




## Mixture Cracking Data

Flexural beam fatigue results indicated lower reduced number of cycles to failure for mixtures with RAS and RAP which was as expected. A similar trend was also observed for the proposed degree of blending analysis.

A significant difference between SCB FI results for Control and 5% RAS mixtures may explain the adverse effects of adding RAS into mixtures. Lower fracture energies from DCT results for mixtures containing RAS or RAP further indicate a disadvantage of adding recycled materials at low temperatures.





## ACKNOWLEDGMENTS

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## CONCLUSIONS

In this study, a new method to quantify the amount of blending that occurs between aged RAS and RAP binders was developed. Local calibration of the Hirsch model was carried out by considering a control mixture containing only virgin materials. Asphalt binder master curves for assumed blending proportions were substituted into the calibrated model which results in an estimation of their corresponding asphalt mixture master curve. Using this method, it was estimated that around 20% to 40% of RAS binder from manufacturer’s shingle waste was activated in the mixture, whereas less than 20% was activated for RAS binder from tear off shingles. Activation of RAP binder was estimated at 40 to 60%. Four-point beam fatigue, SCB, and DCT test configurations were implemented to further investigate the degree of blending results from a cracking perspective. In all cases a consistent trend was observed between the results of mixture cracking tests and the PG of the proposed degree of binder blending.