Using Plastic Deformation to improve predictions of Phase Angles from Dynamic Modulus Data

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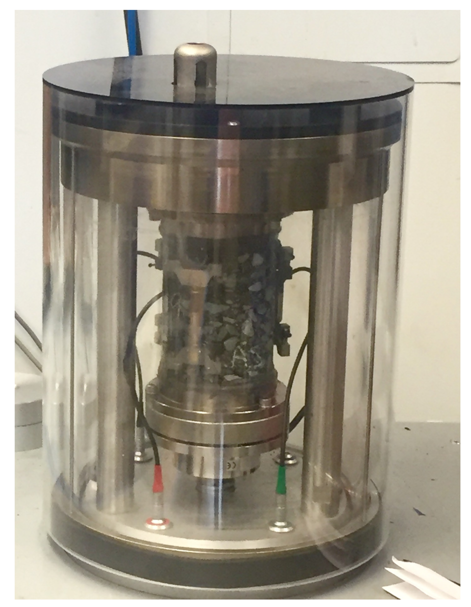
Abstract

During Dynamic modulus tests small amounts of plastic deformation are not considered. Useing data from Oshone, et al. to evaluate if plastic deformation contributed when we try to predict phase angle from stiffness data. While the analysis of plastic deformation was successful and the strain-time graphs had the expected curvature. There does not appear to be arelationship between those graphs and the phase angle predictions of Oshone, et al.

Introduction/Background

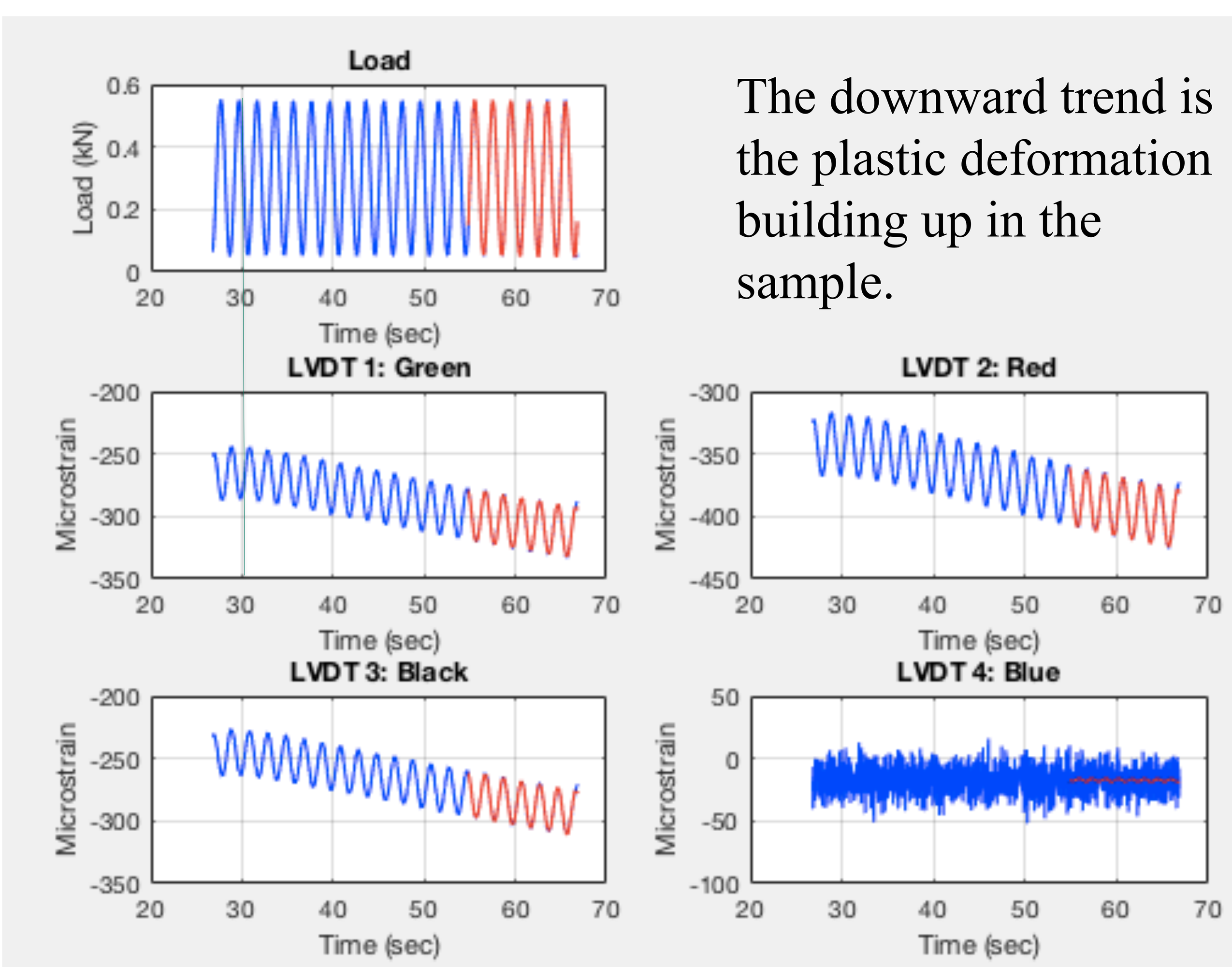
Multiple asphalt samples

- The dynamic modulus is a property of viscoelastic materials(ratio of stress to strain)
- The phase angle indicates the lag between the stress and the strain.
- Current predictive phase angle models of asphalt use stress and strain data to predict the dynamic modulus and phase angle of the asphalt.
- During dynamic modulus tests small amounts of plastic deformation are not considered.



Asphalt sample with LVDTs

Methods



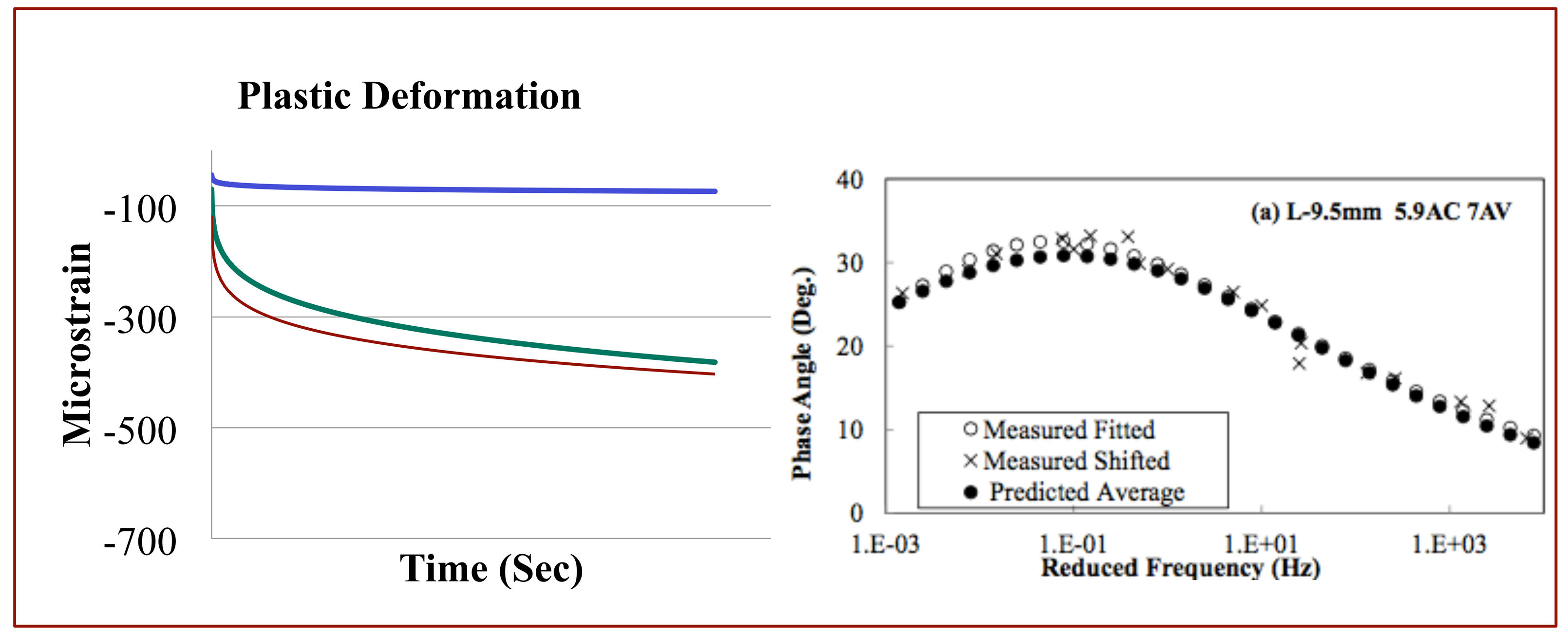
The downward trend is the plastic deformation building up in the sample.

- A script was created and used in MATLAB to simplify the data analysis process
- Plastic deformation at the minimum displacement of each cycle was plotted
- The data from all available LVDTs were averaged
- These were then combined with the six other frequencies tested
- Replicates were then averaged to create a final graph for that temperature and mix
- This process was repeated for each temperature and mixture

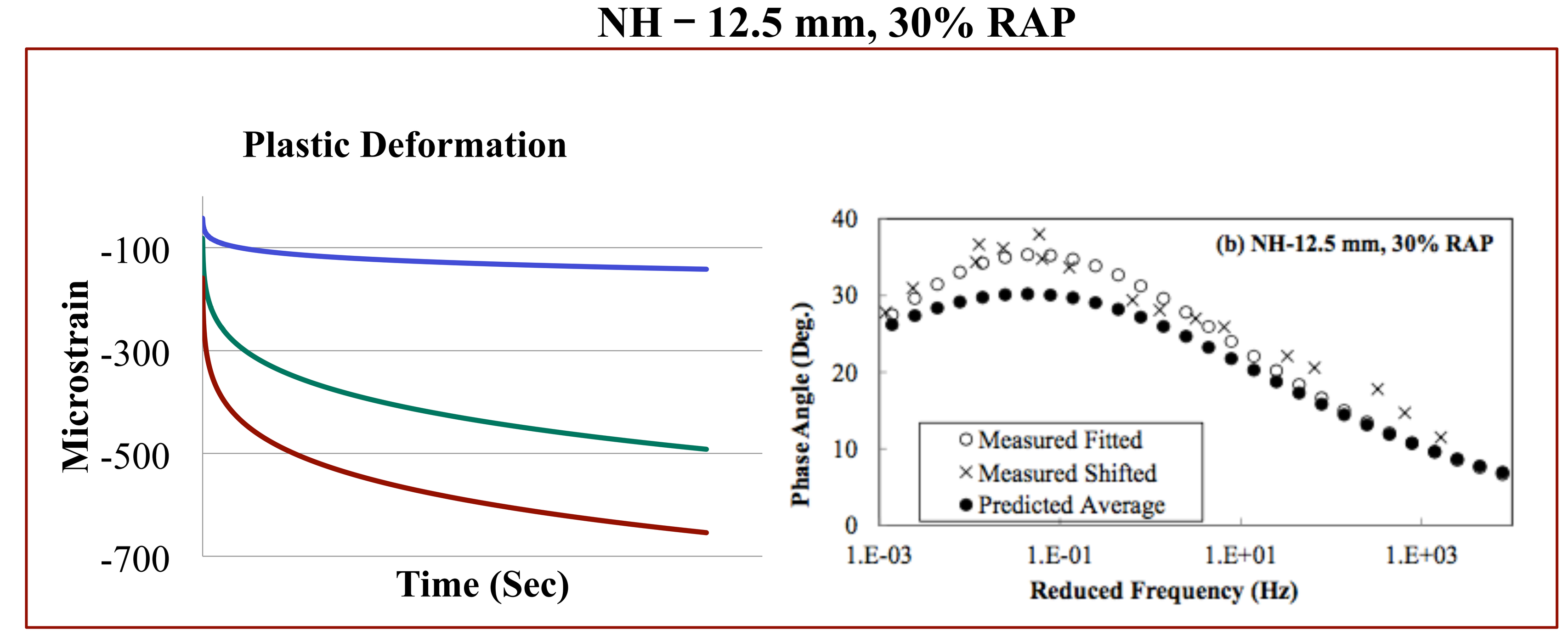
Results/Discussion

Mixture Label	RMSE of Phase Angle prediction	Maximum Strain		
		4.4C	21.1C	37.8C
L - 9.5 mm, 5.9AC 7AV	0.85	-73	-381	-403
C – 12.5 mm, 6.1AC 7AV	8.65	-253	-497	-637
NH – 12.5 mm, 30% RAP	2.40	-141	-491	-654
NH – 19 mm, RAPRAS	6.03	-131	-494	-663

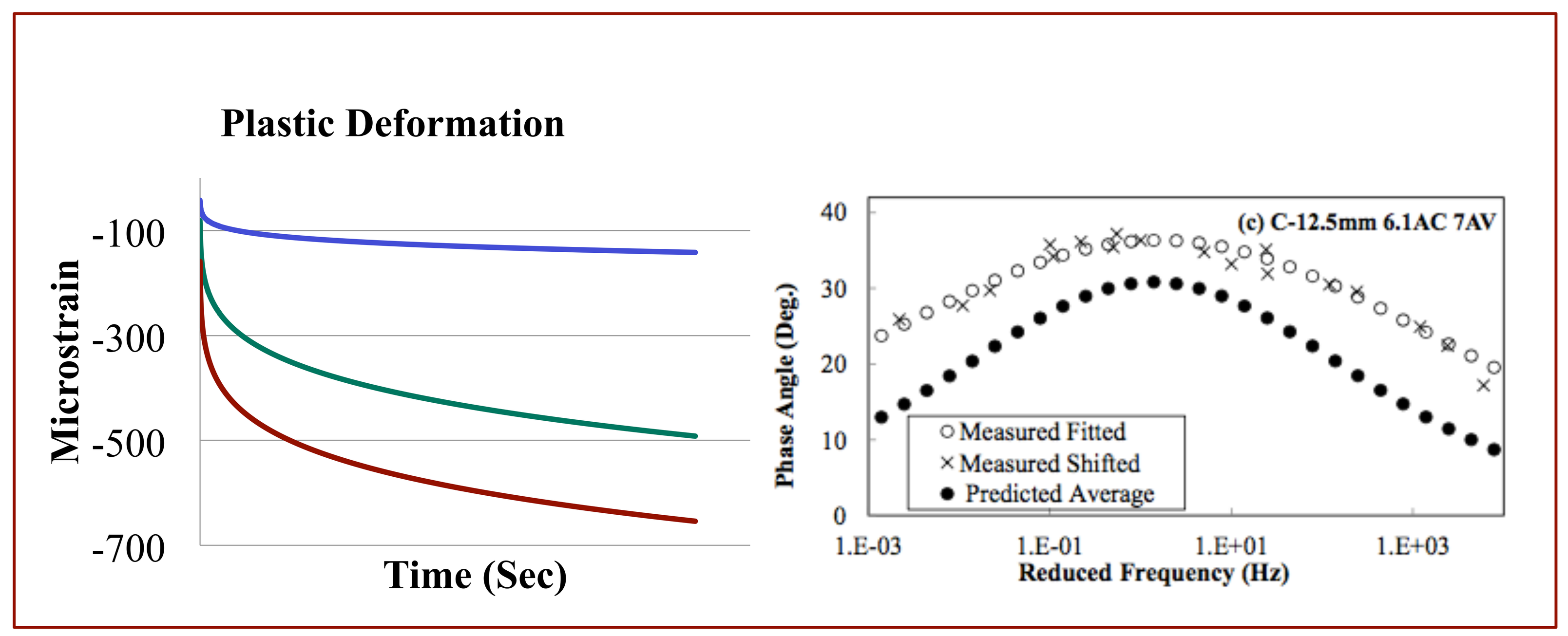
L-9.5 mm, 5.9AC 7AV



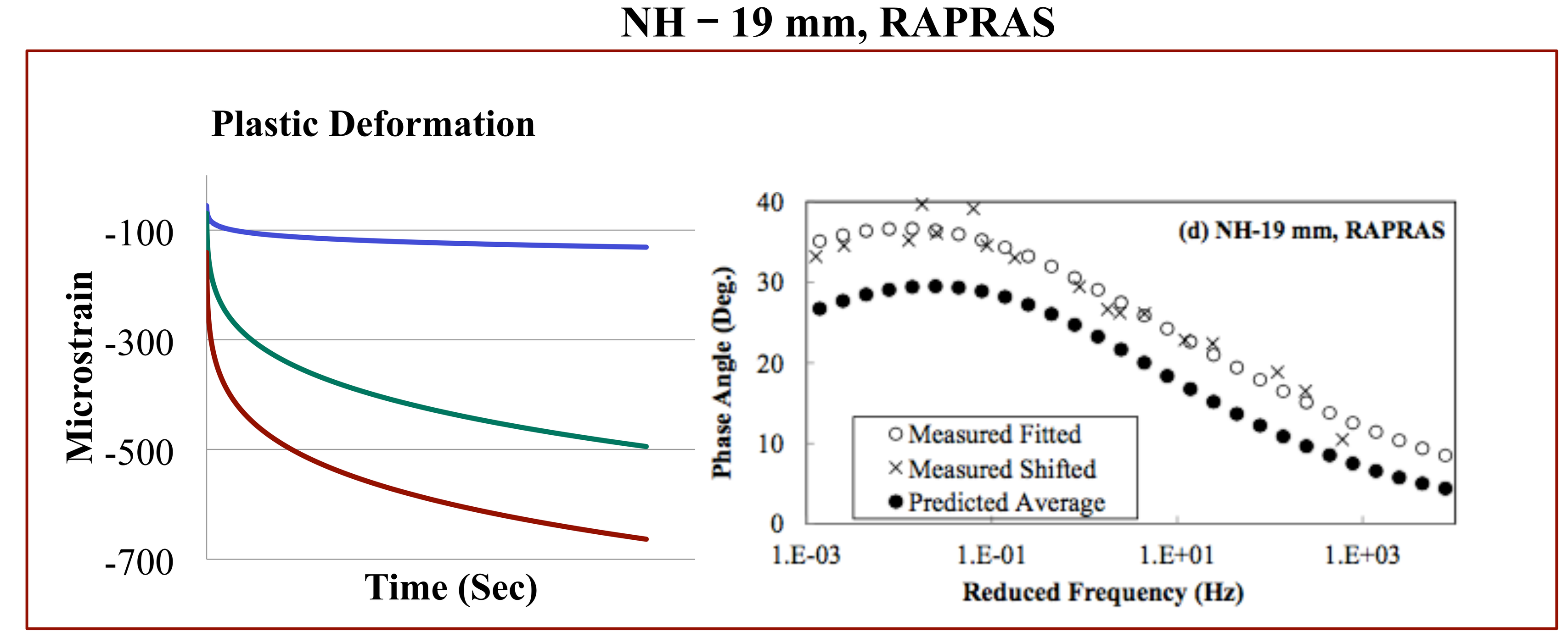
NH – 12.5 mm, 30% RAP



C – 12.5 mm, 6.1AC 7AV



NH – 19 mm, RAPRAS



- Maximum plastic strain is larger in the Rode Island mixtures with a larger RMSE
- Maximum plastic strain increases with temperature
- This is expected but does not seem to indicate a way to improve the phase angle model

- L-9.5mm, 5.9AC 7AV has the lowest RMSE and the lowest plastic strain
- The NH samples have a percent difference of 150% RMSE
- The maximum plastic strain of those samples changes very little

Conclusions/Future Work

- Using the LVDT data it was possible to find the plastic deformation of the material
- Range of frequencies and temperatures was combined to create a model of the relaxation of the material
- Graphs of plastic deformation do not seem to indicate a possible method of improving the phase angle predictions.
- Additional samples could be analyzed to further investigate the contribution of plastic deformation on phase angle

Literature Cited

Oshone, MirKat, Eshan Dave, Jo Sias Daniel, and Geoffrey M. Rowe. "Prediction of Phase Angles from Dynamic Modulus Data and Implications on Cracking Performance Evaluation." AAPT (2017)

Acknowledgements

This research was supported with funding from the National Science Foundation's Research Experience for Teachers in Engineering Grant (ENG-1132648).
Thanks to Reyhaneh Rahbar-Rastengar, Stephan Hale, Kiley Remiszewski and the Leitzel center