Summary Report

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Introduction

The objective of the research performed was to test and analyze asphalt samples with differing characteristics. The three main tests used to analyze the asphalt samples were the viscometer, the dynamic shear rheometer (DSR), and the bending beam rheometer (BBR). Plots were made in order to compare the results obtained.

Results and Discussion

For the asphalt samples tested, the first test run was the viscometer (figure 1). The viscometer has the job of testing the viscosity of the asphalt binder. The viscosity was tested starting at 60°C and ending at 180°C, increasing at 10° intervals. After testing the asphalts' viscosity, the following plot (figure 2) was made to show the difference between the two asphalt binders. The plot shows that binder #1 (regardless of the temperature) is a more viscous fluid.

Figure 1

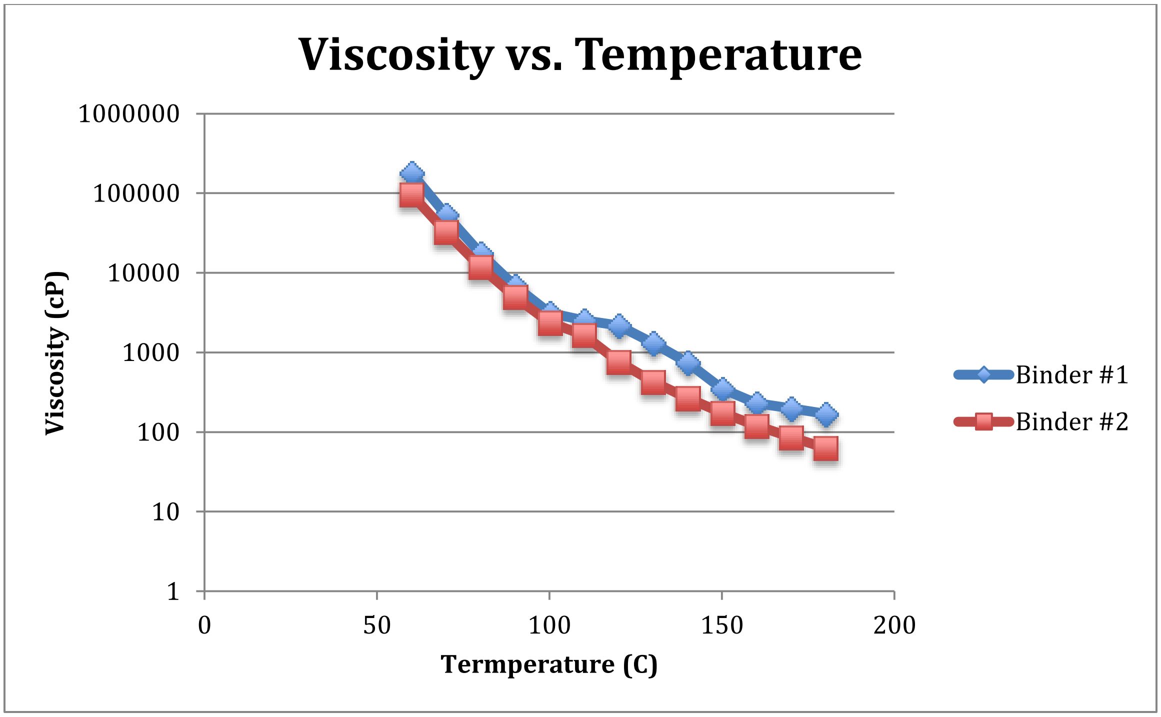

Figure 2

The next test performed on the asphalt binders was the dynamic shear rheometer (DSR). The DSR (figure 3), like the viscometer, tested the different asphalt samples at varying temperatures. The results obtained in a typical DSR test include: the frequency, the shear stress, the strain, the phase angle, the viscous modulus, the elastic modulus, and the complex modulus (G*), the most important of these results being the complex modulus. The following plot of G* vs. frequency (figure 4) shows the results obtained for the different asphalt samples at 76°C.

Figure 3

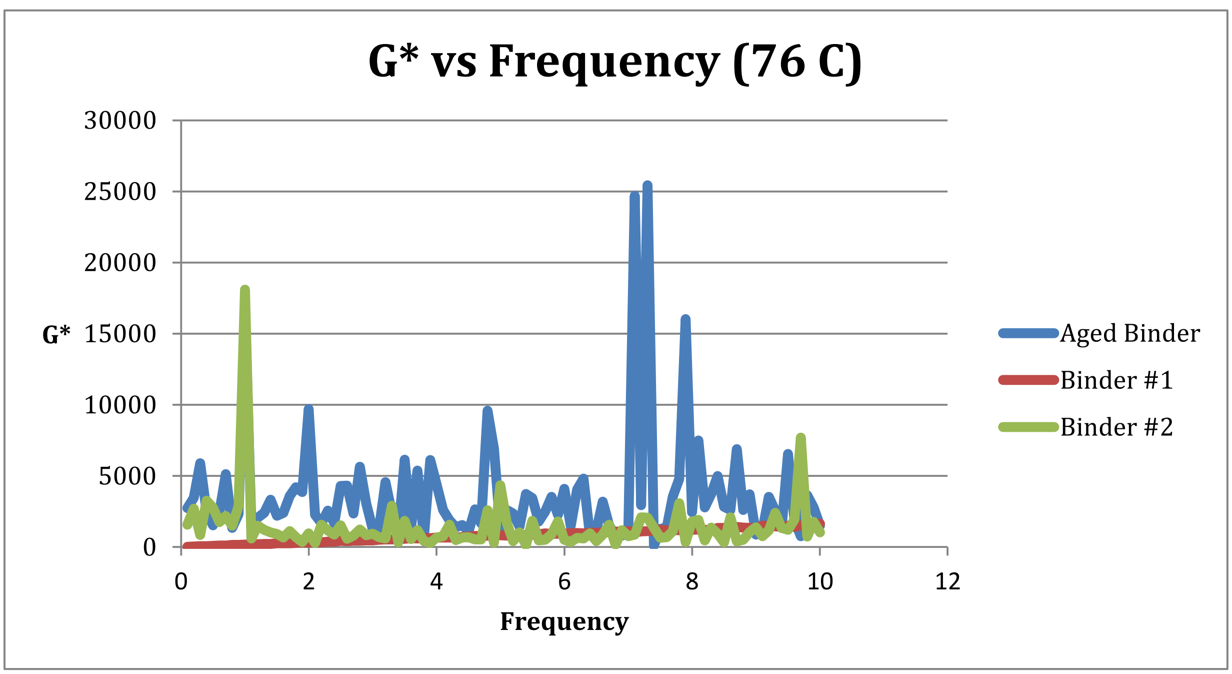

Figure 4

The last test run for the asphalt samples was the bending beam rheometer (BBR). The BBR (figure 5) gives us the stiffness by measuring the amount of deflection that the asphalt beam has under a given load. Since asphalt is affected by temperature, the BBR testing was also done for several different temperatures. The stiffness is found using the equation, S(t)= $PL^3/(4bh^3 * \delta)$. In this equation, P is the applied load, L is the span length, b is the beam width, h is the beam height, and δ is the deflection. Although the computer program used to run the test would be able to give you the stiffness, it is still important to know and understand the equation used to obtain the stiffness.

Figure 5

Conclusion

There are many different components of asphalt that help define its behavior and functions. The viscosity, the complex shear modulus, and the stiffness are among those components that are especially important when trying to understand the behavior of asphalt. Another thing that must be taken into account when dealing with asphalt is the temperature of its surroundings (especially in the Midwest where the temperature in the summer and winter can differ by 100°F). In every test that was run, the temperature played a large role in the results obtained. With the viscometer, the larger the temperature the less viscous the asphalt binder was. For the BBR test, the colder the temperature was the stiffer the asphalt beam turned out to be.

Research Summary

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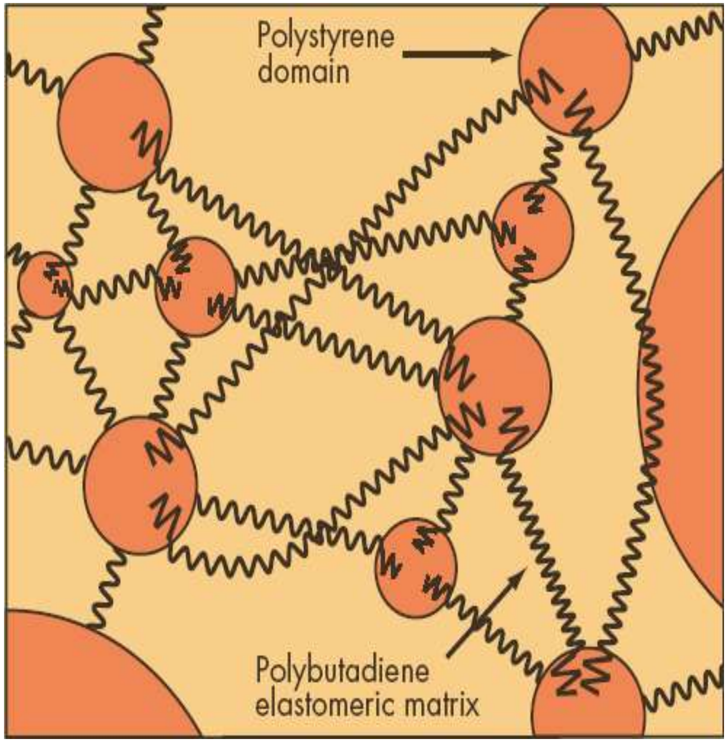
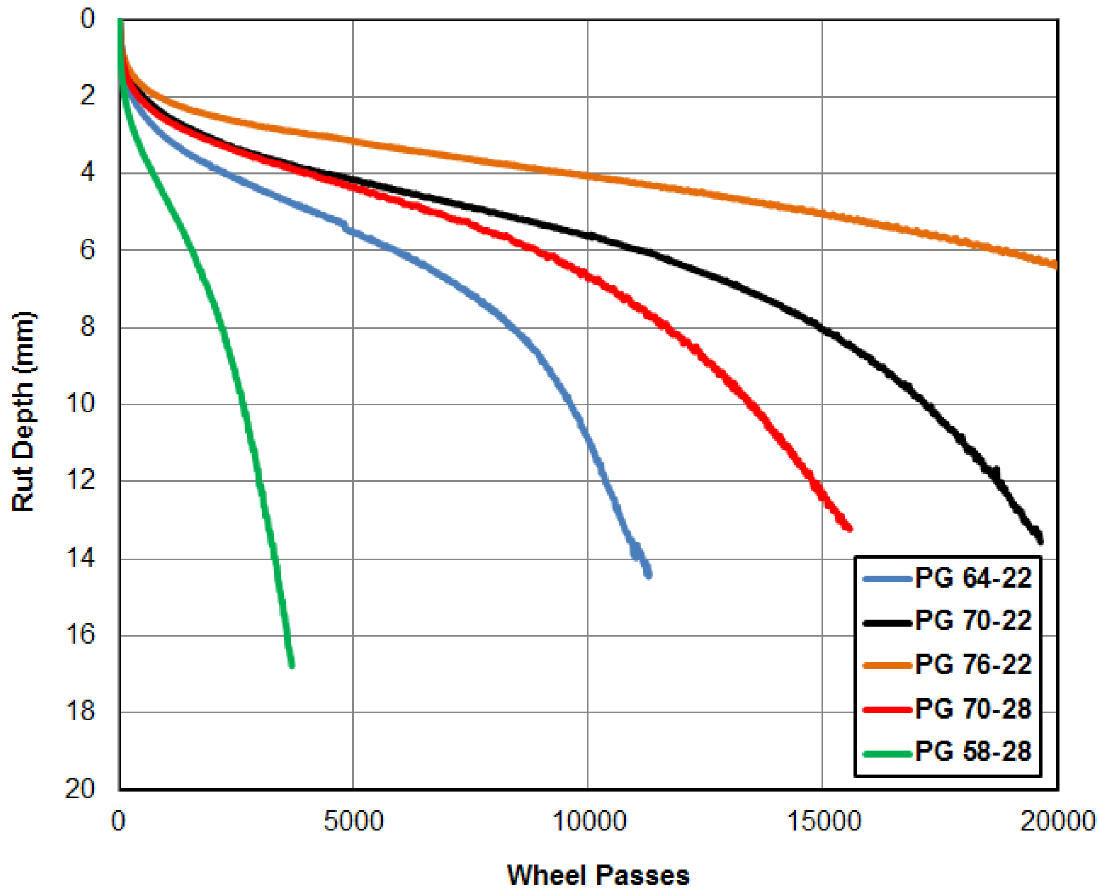
Polymer Study

- Study Objectives
  - Identify the effects of SBS polymer and PG grade on high and low temperature asphalt mixture properties
  - Investigate local strain field properties of polymer-modified asphalt mixtures at low temperatures
- Asphalt Materials
  - PG 64-22
  - PG 58-28
  - PG40-40
  - PG 70-22 (1.4% SBS)
  - PG 70-28 (2.3% SBS)
  - PG76-22 (3.0% SBS)



SBS Polymer Chains

Hamburg Wheel Tracking Results

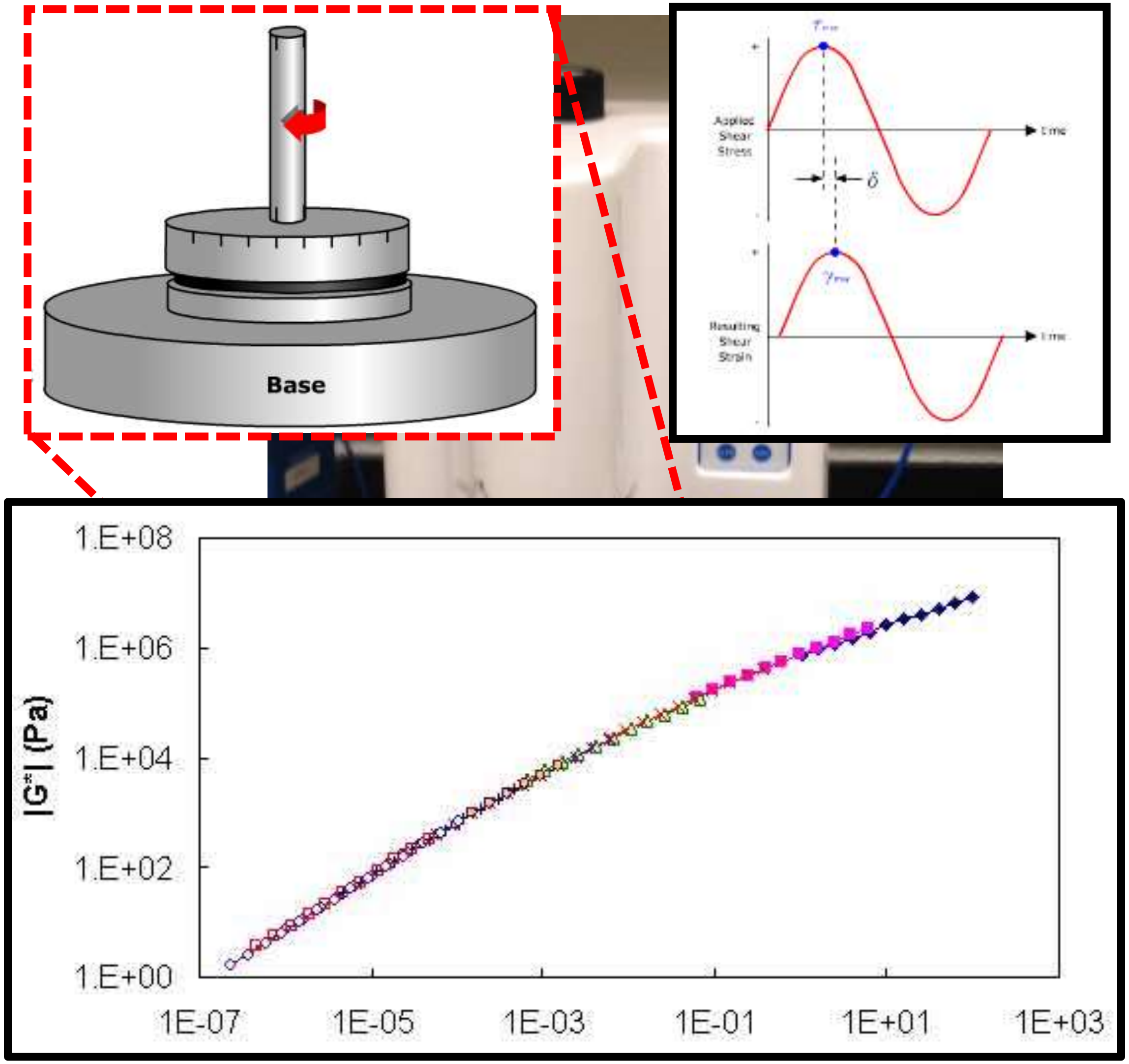


Provided by Brian Hill

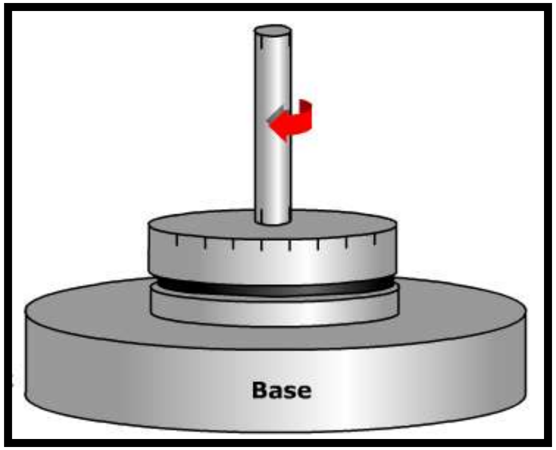
Undergraduate Research Study Goals

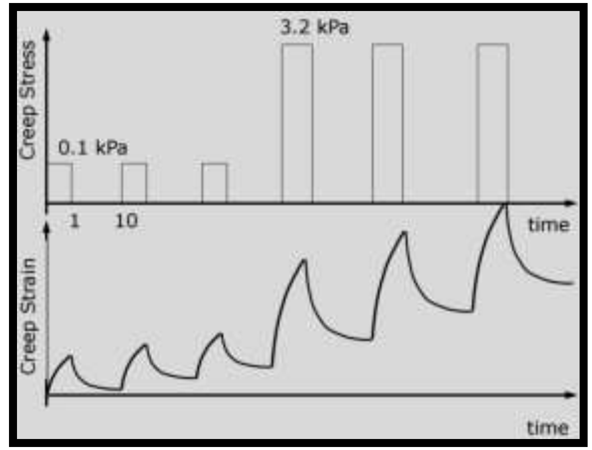
- Test binders using the MSCR program developed by Malvern for the Bohlin DSR
- Test neat and polymer-modified binders in a temperature and frequency sweep using DSR
- Identify correlations between Hamburg mixture and DSR-measured binder shear moduli or MSCR test parameters

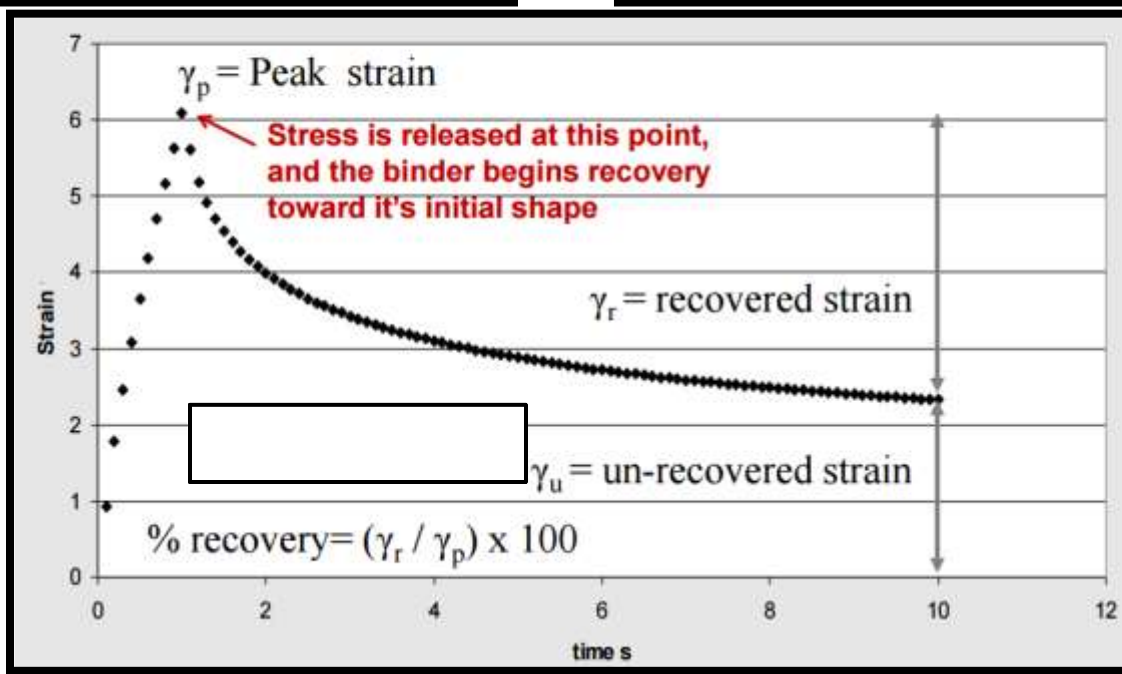
Dynamic Shear Rheometer



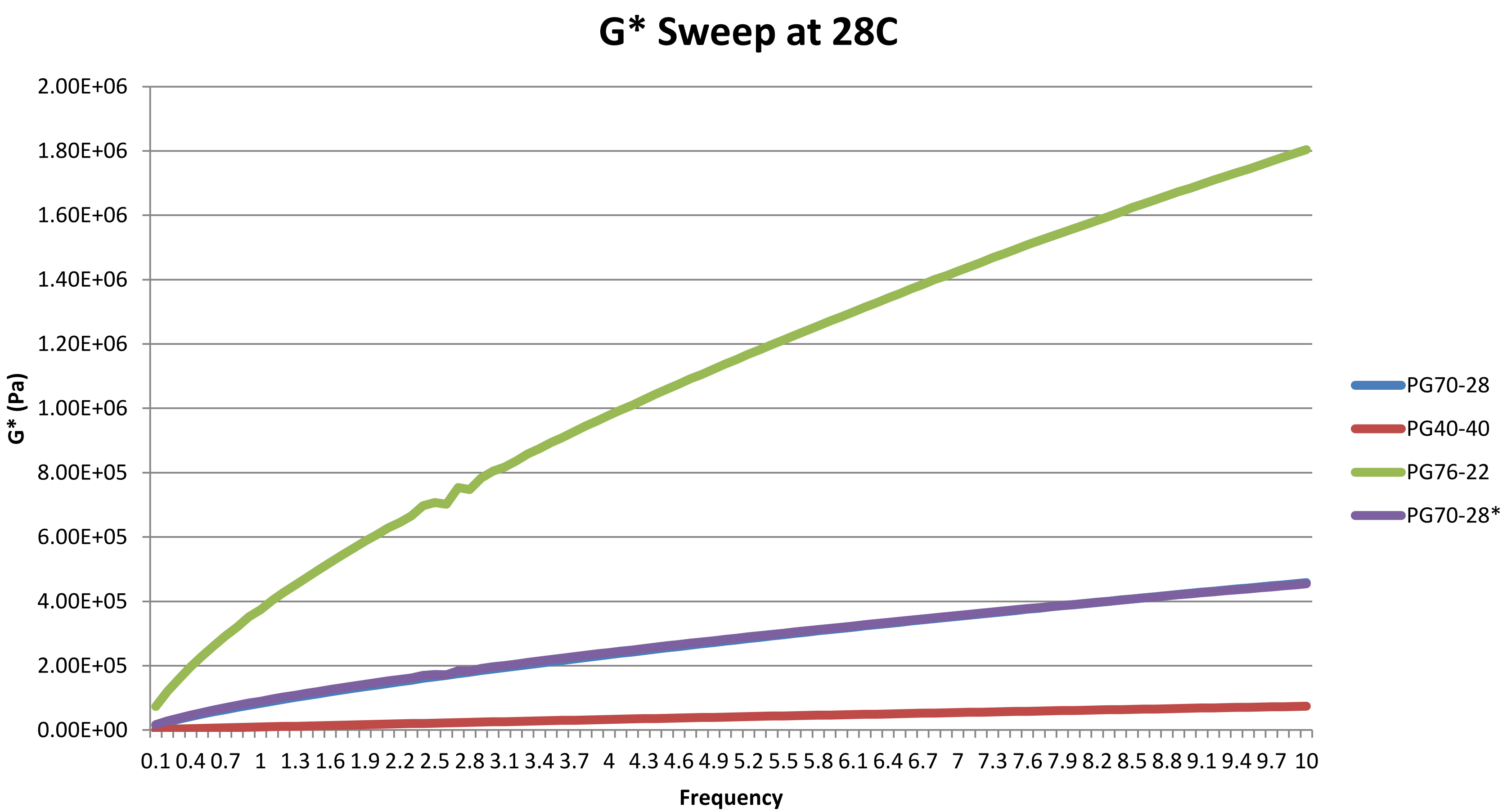
Multiple Stress Creep Recovery (MSCR) Test



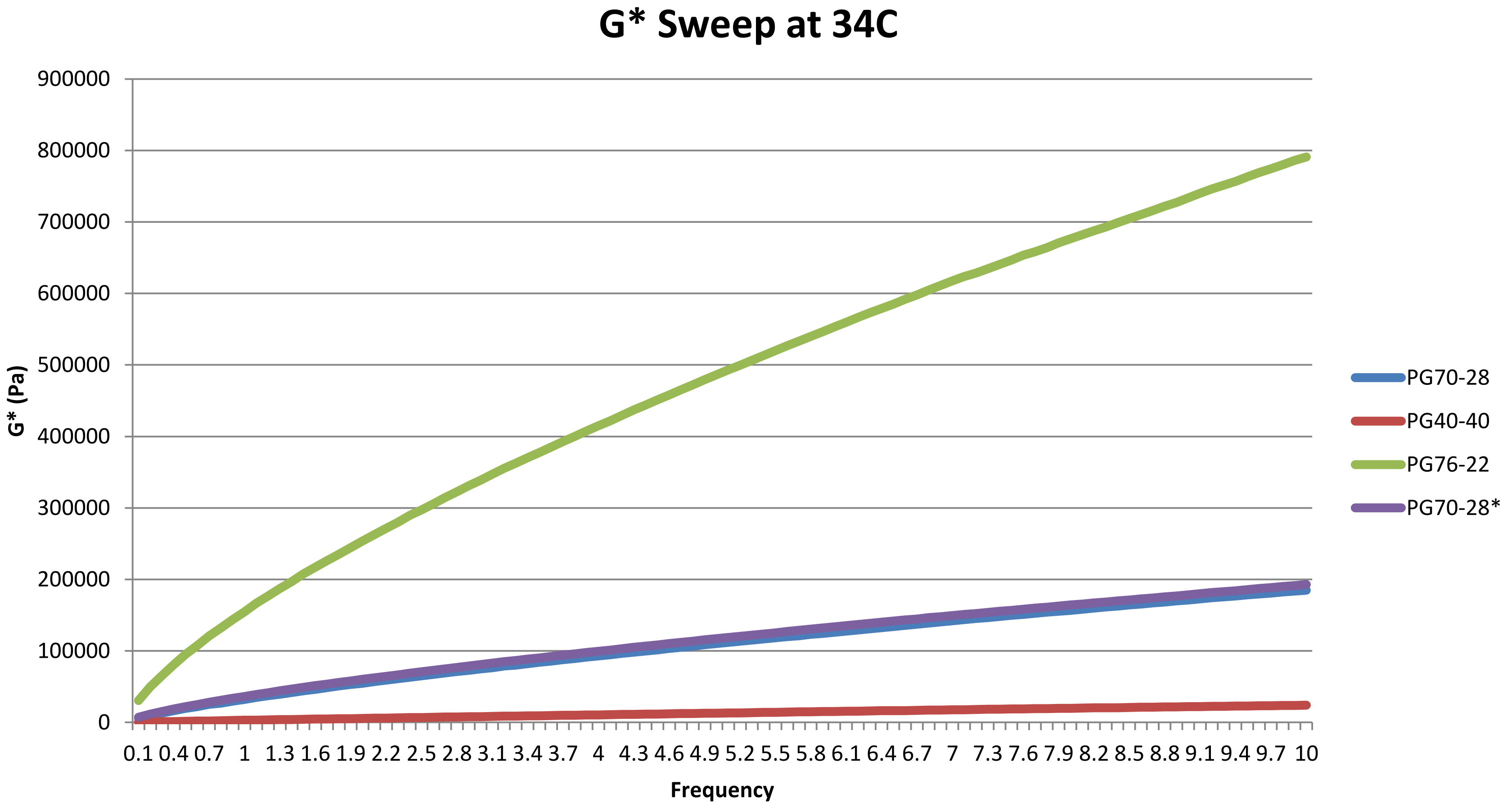




G* Sweeps

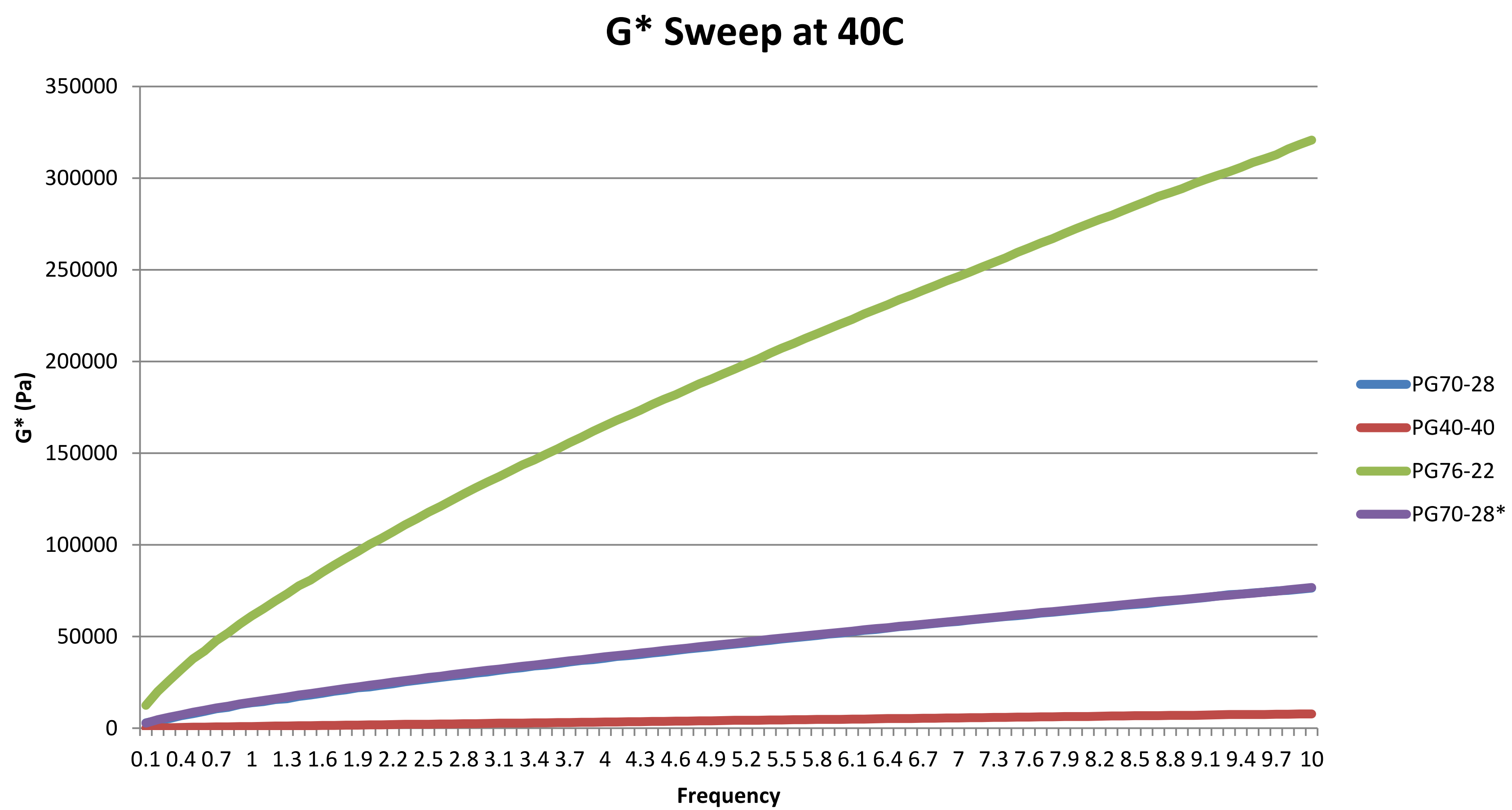

G* Sweep at 28C
2.00E+06
1.80E+06
1.60E+06
1.40E+06
1.20E+06
1.00E+06
8.00E+05
6.00E+05
4.00E+05
2.00E+05
0.00E+00
G* (Pa)
0.1 0.4 0.7 1 1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4 3.7 4 4.3 4.6 4.9 5.2 5.5 5.8 6.1 6.4 6.7 7 7.3 7.6 7.9 8.2 8.5 8.8 9.1 9.4 9.7 10
Frequency
PG70-28
PG40-40
PG76-22
PG70-28*

G* Sweeps



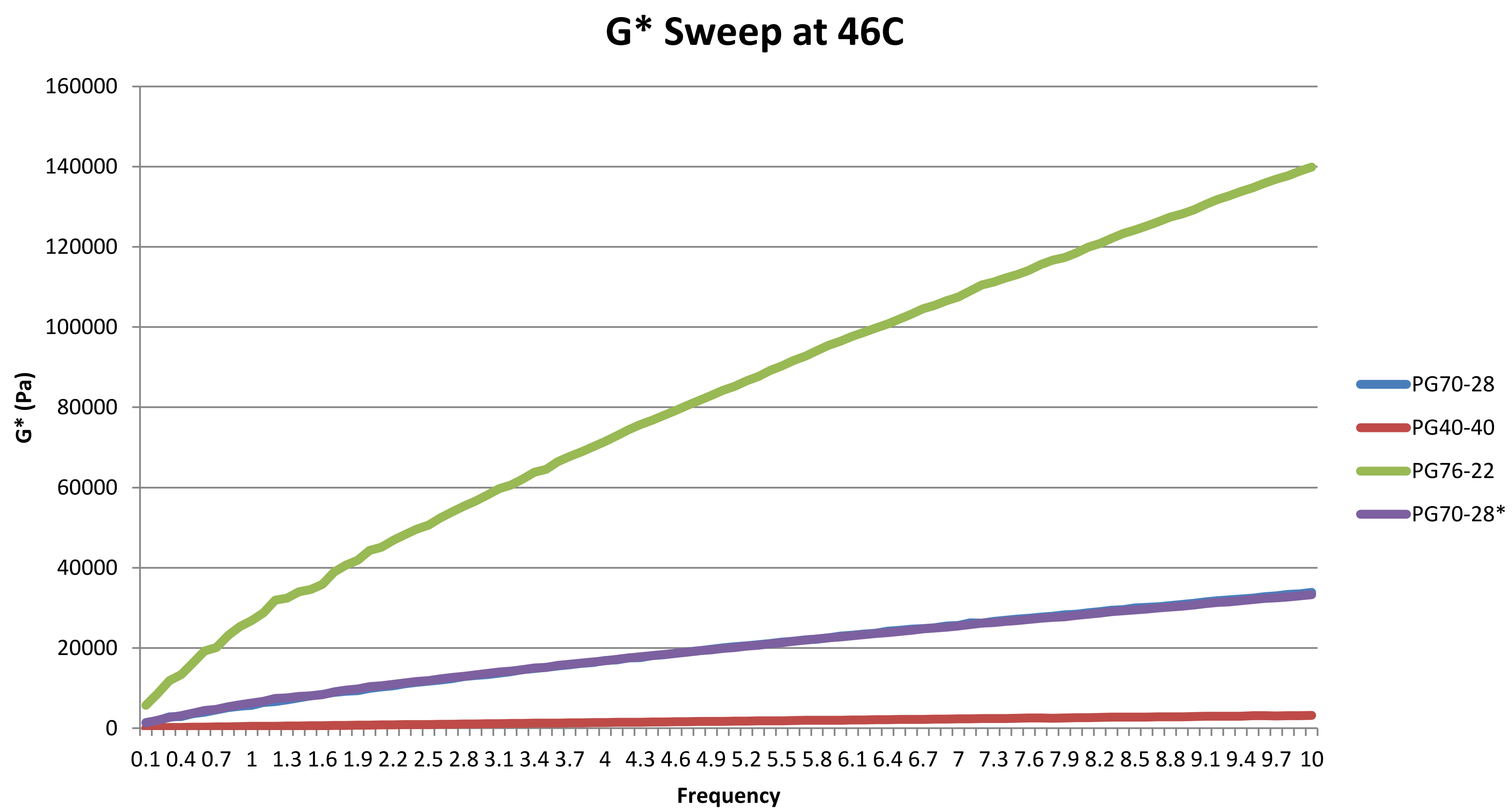
G* Sweep at 34C
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
G* (Pa)
0.1 0.4 0.7 1 1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4 3.7 4 4.3 4.6 4.9 5.2 5.5 5.8 6.1 6.4 6.7 7 7.3 7.6 7.9 8.2 8.5 8.8 9.1 9.4 9.7 10
Frequency
PG70-28
PG40-40
PG76-22
PG70-28*

G* Sweeps

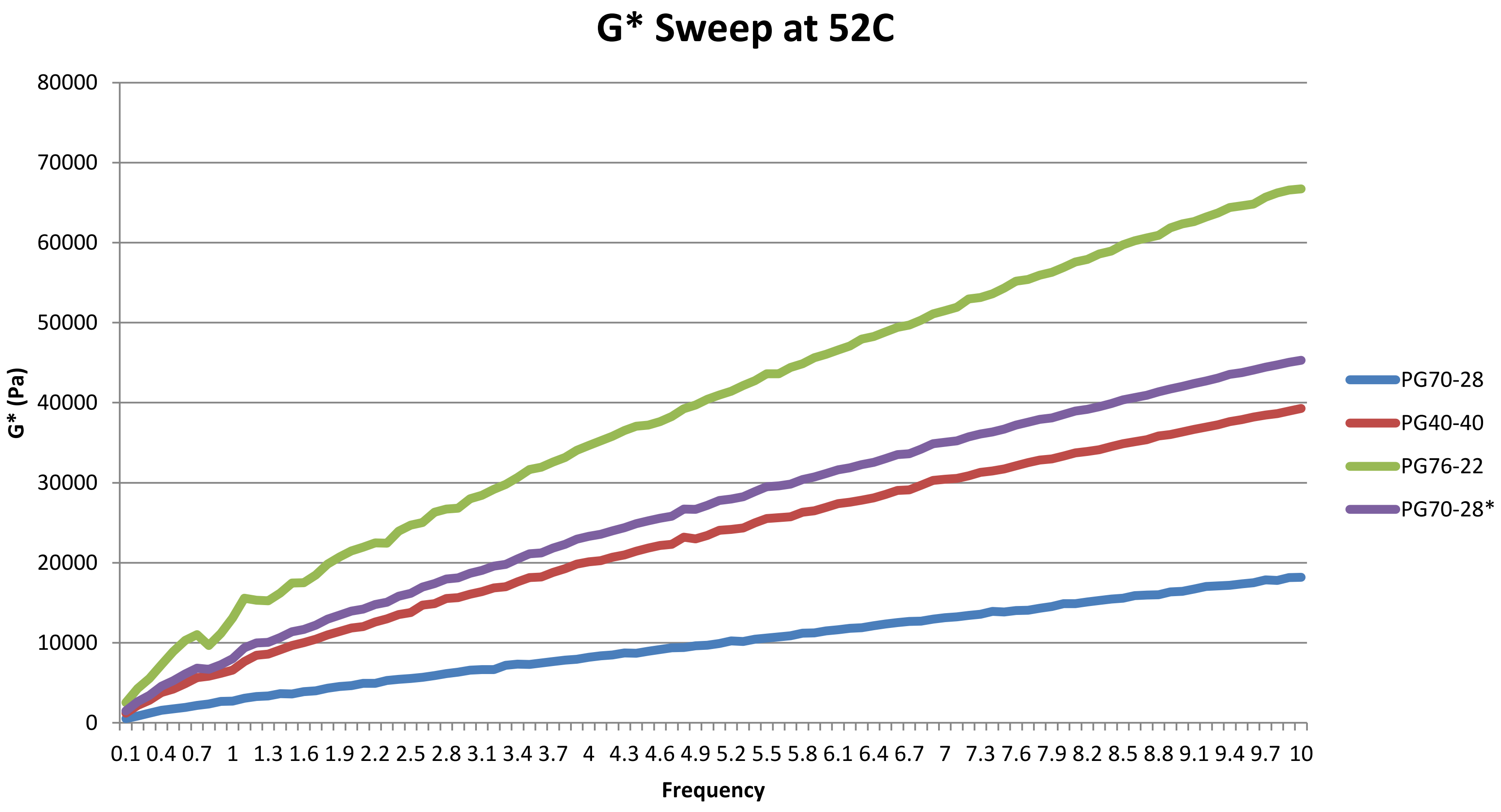


G* Sweep at 40C
350000
300000
250000
200000
150000
100000
50000
0
G* (Pa)
0.1 0.4 0.7 1 1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4 3.7 4 4.3 4.6 4.9 5.2 5.5 5.8 6.1 6.4 6.7 7 7.3 7.6 7.9 8.2 8.5 8.8 9.1 9.4 9.7 10
Frequency
PG70-28
PG40-40
PG76-22
PG70-28*

G* Sweeps

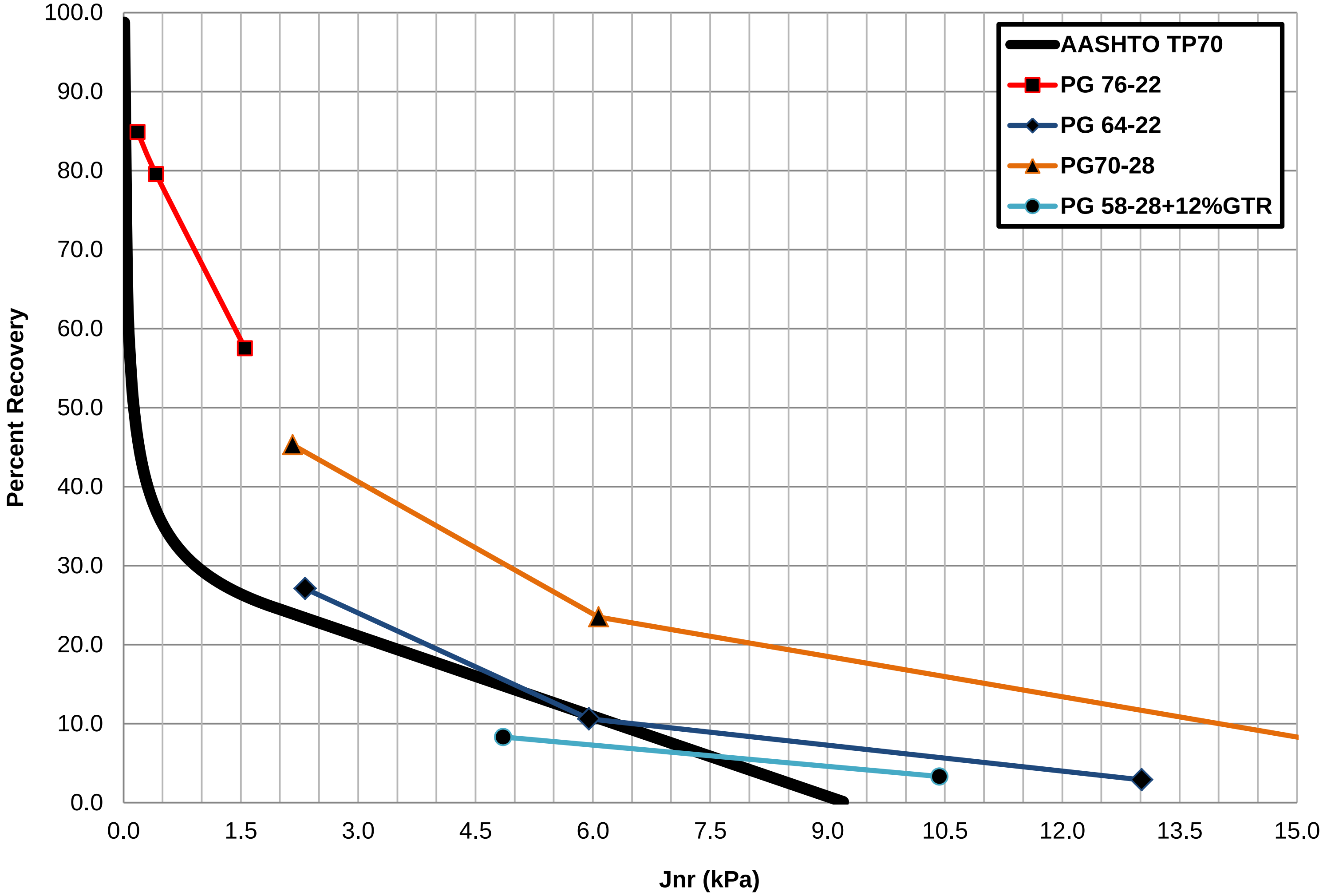

G* Sweep at 46C
160000
140000
120000
100000
80000
60000
40000
20000
0
G* (Pa)
0.1 0.4 0.7 1 1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4 3.7 4 4.3 4.6 4.9 5.2 5.5 5.8 6.1 6.4 6.7 7 7.3 7.6 7.9 8.2 8.5 8.8 9.1 9.4 9.7 10
Frequency
PG70-28
PG40-40
PG76-22
PG70-28*

G* Sweeps



G* Sweep at 52C
80000
70000
60000
50000
40000
30000
20000
10000
0
G* (Pa)
0.1 0.4 0.7 1 1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4 3.7 4 4.3 4.6 4.9 5.2 5.5 5.8 6.1 6.4 6.7 7 7.3 7.6 7.9 8.2 8.5 8.8 9.1 9.4 9.7 10
Frequency
PG70-28
PG40-40
PG76-22
PG70-28*

MSCR Data Plot



Future Applications of Work

- Feeder data for prediction of Hamburg-DC(T) data
  - J_{nr} or G* could be used in conjunction with a micromechanical-esque analysis to avoid additional Hamburg wheel tracking tests