Statistical Analysis of Dynamic Modulus and Phase Angle to Evaluate Effects of Aging on Mix Linear Viscoelastic Properties

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Introduction

- **Essential Question**: How do properties of viscoelastic material (E* and δ) change with different aging levels?
- Stiffness (E*) → cracking
- Relaxation (δ) → decreases as aging increases
- Cracking→ Changes over time as asphalt material ages.
- Increase of Temperature → effect on aging rate
- Binder Aging → effect on asphalt mixture performance.
- Higher E* → More stiffer (rutting)
- Ideal mixture → Lower E* and Higher δ

Methods

- Complex Modulus Testing
- Short Term vs. Long Term Aging (Simulate in the lab setting)
  - STOA
  - 24 Hours,135° C
  - 5 Days, 95° C
  - 12 Days, 95° C

Binder Grade (PG)	Aggregate Size (mm)
58-28	12.5
52-34	12.5
58-28	19
52-34	19

- Statistical Analysis (T-Test)
  - Level of Significance → .05
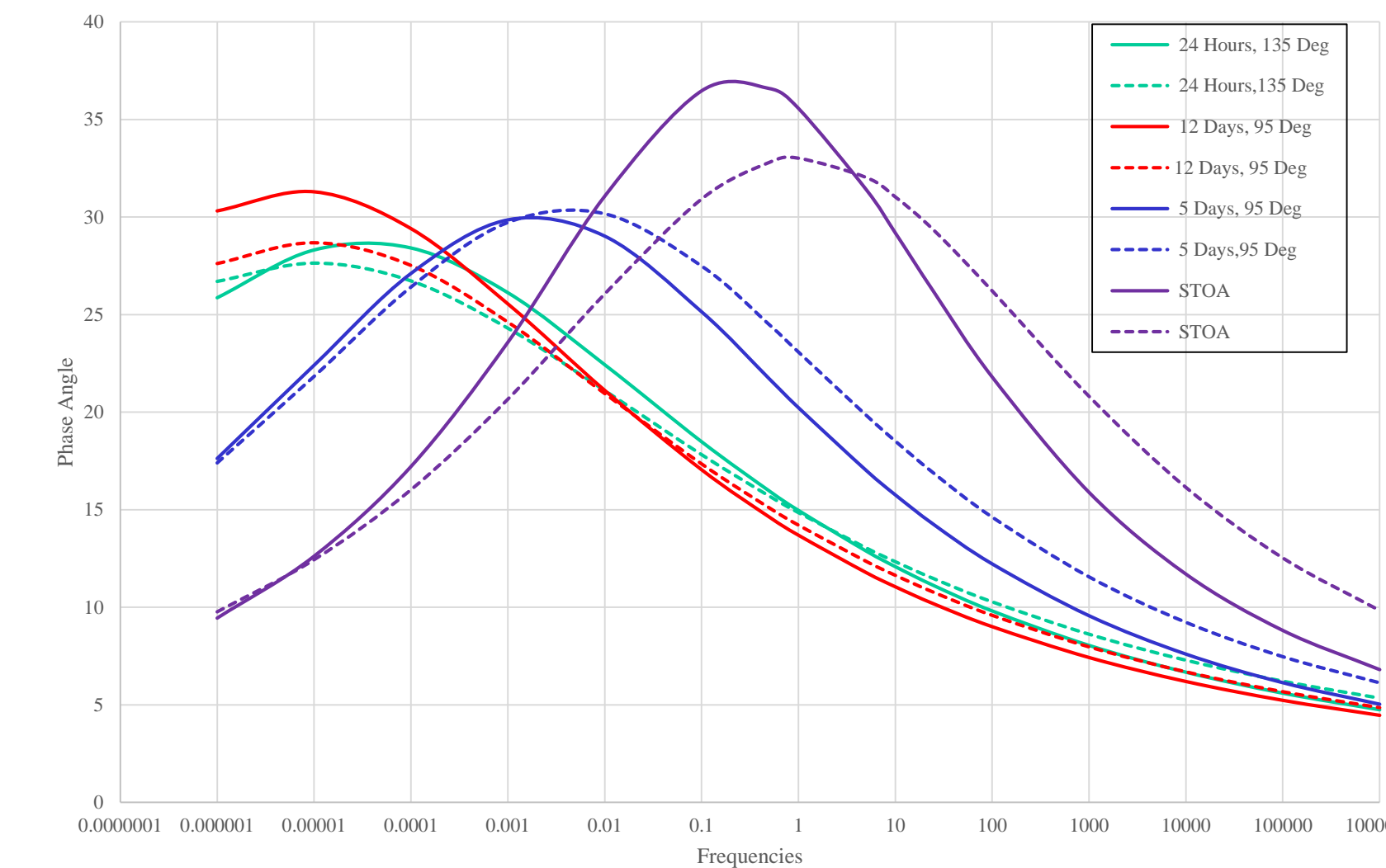 - P-Values less than .05→ statistical significance

Results

Different binders w/same aggregate and aging level

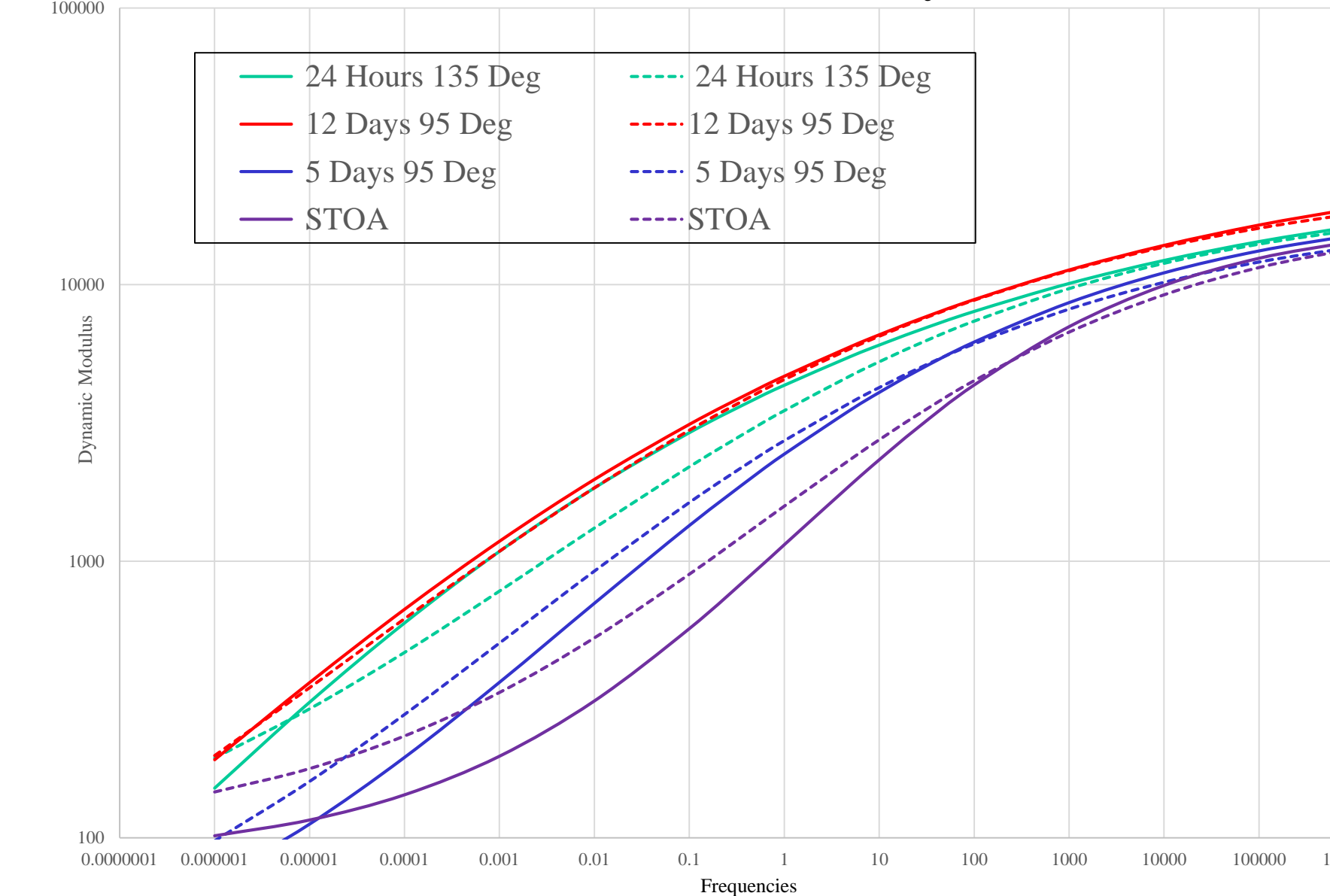PG 58-28,12.5 vs. PG 52-34,12.5 (Dynamic Modulus)
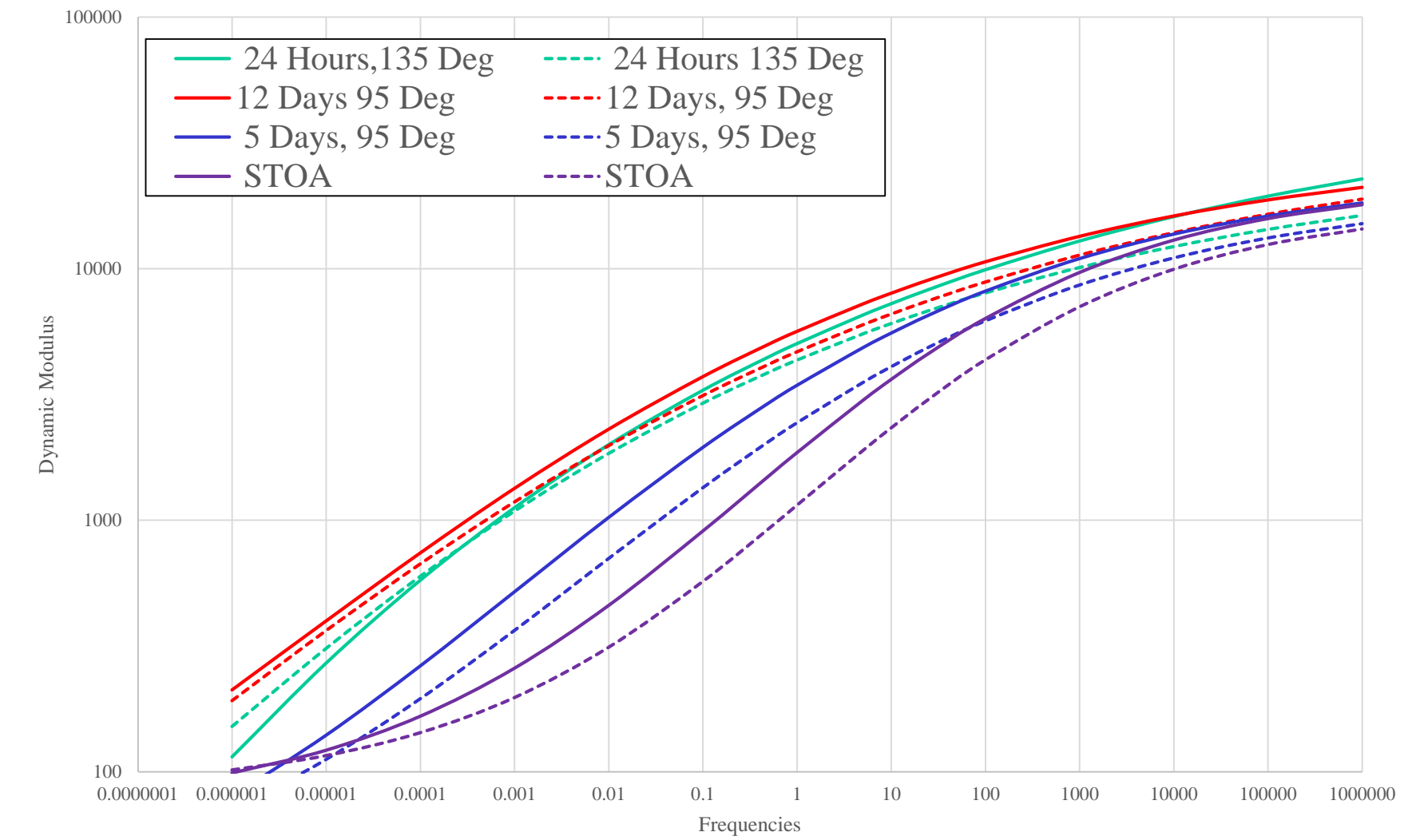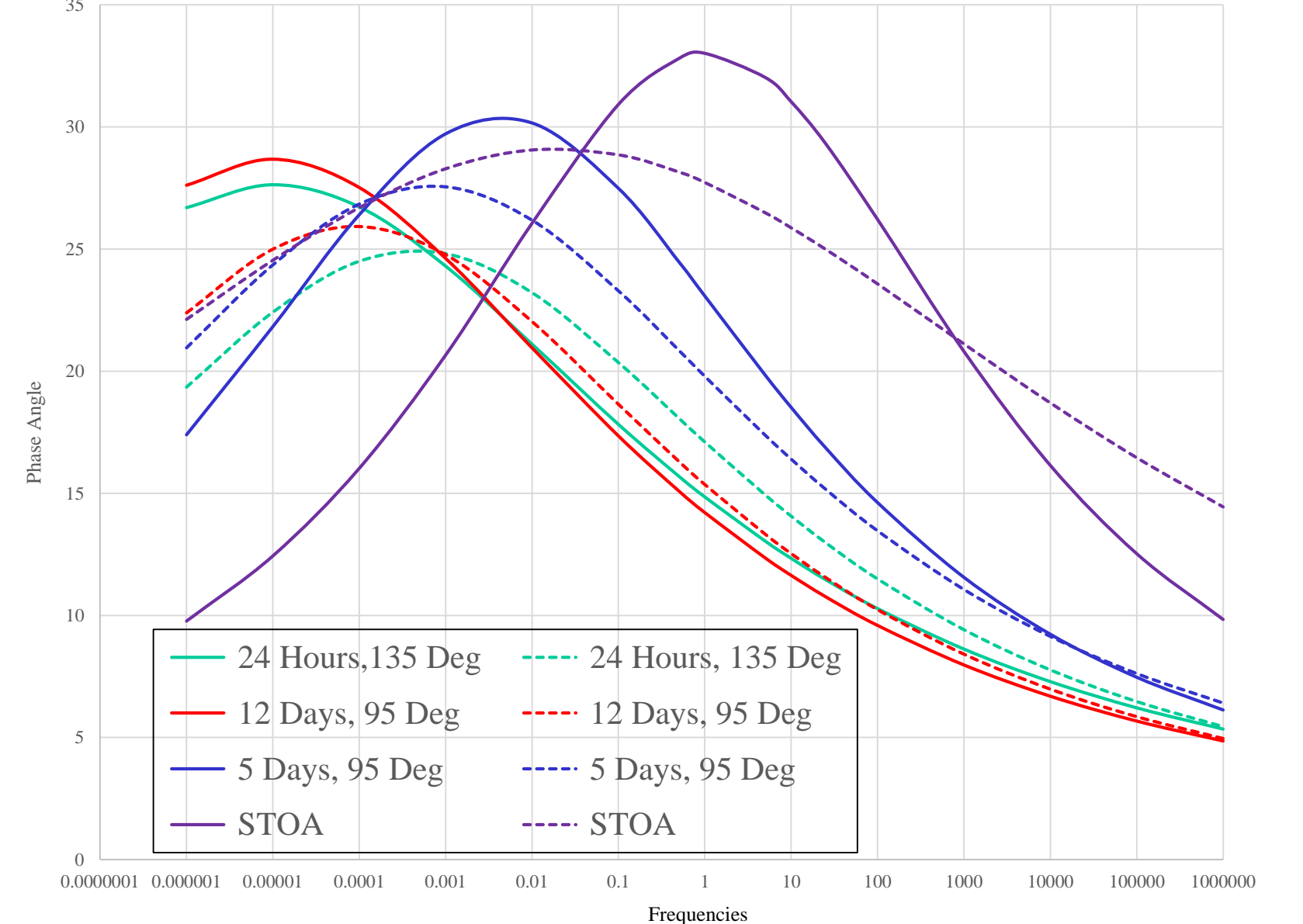
PG 58-28,12.5 vs. PG 52-34,12.5 (Phase Angle)

Different aggregate w/same binder and aging level

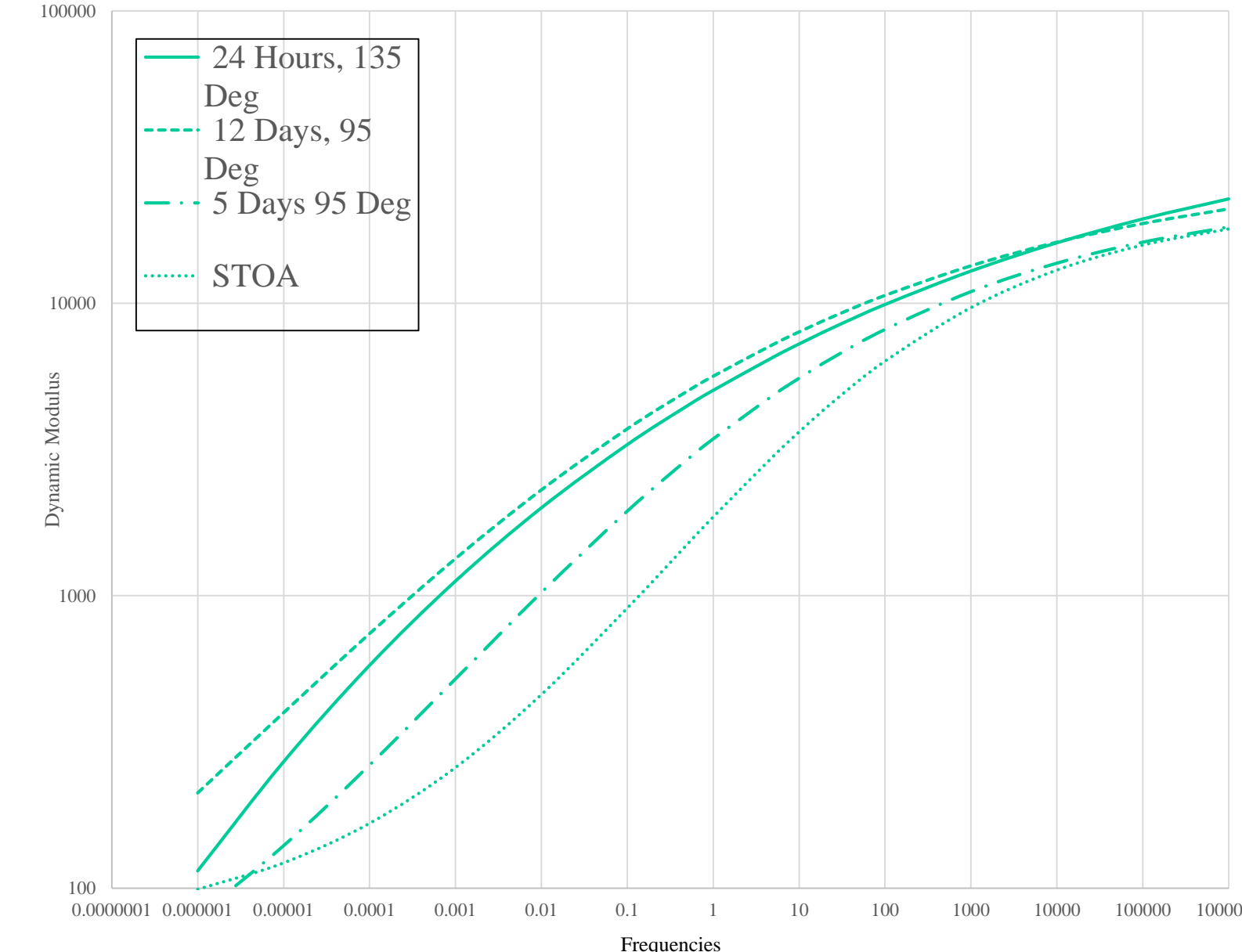PG 52-34,12.5 vs. PG 52-34,19 (Dynamic Modulus)
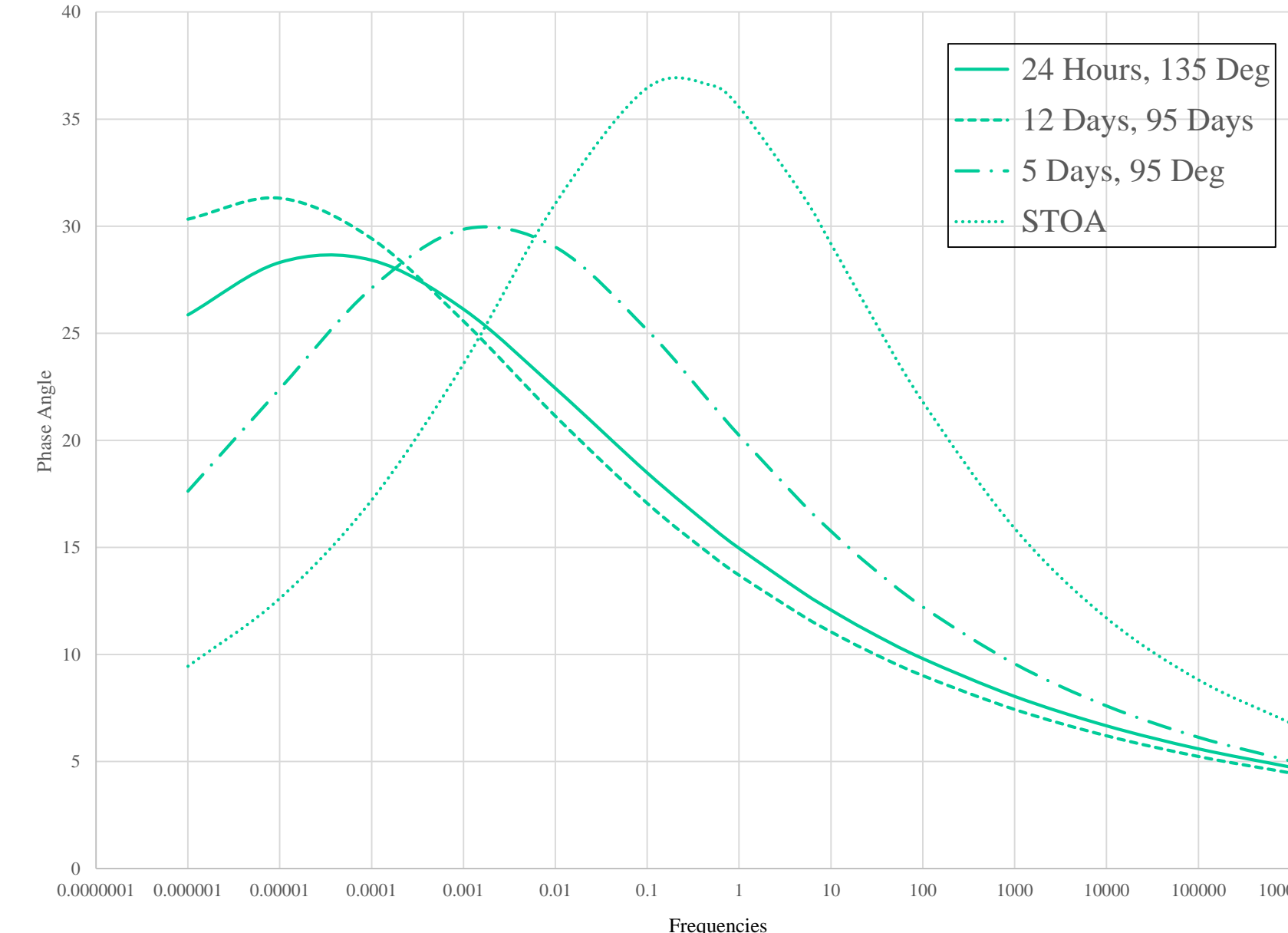
PG 52-34,12.5 vs. PG 52-34,19 (Phase Angle)

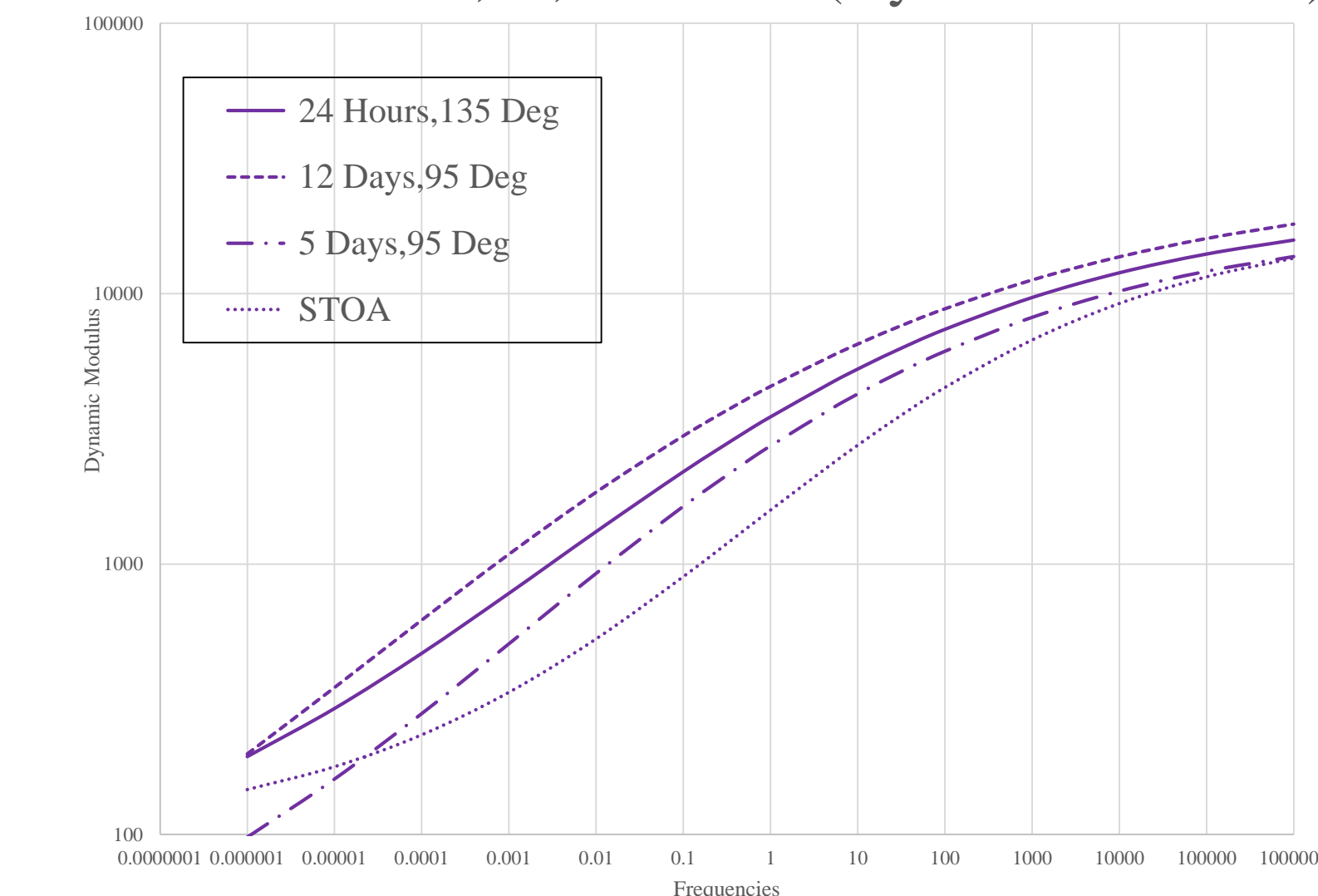### Different aging level w/same binder and aggregate

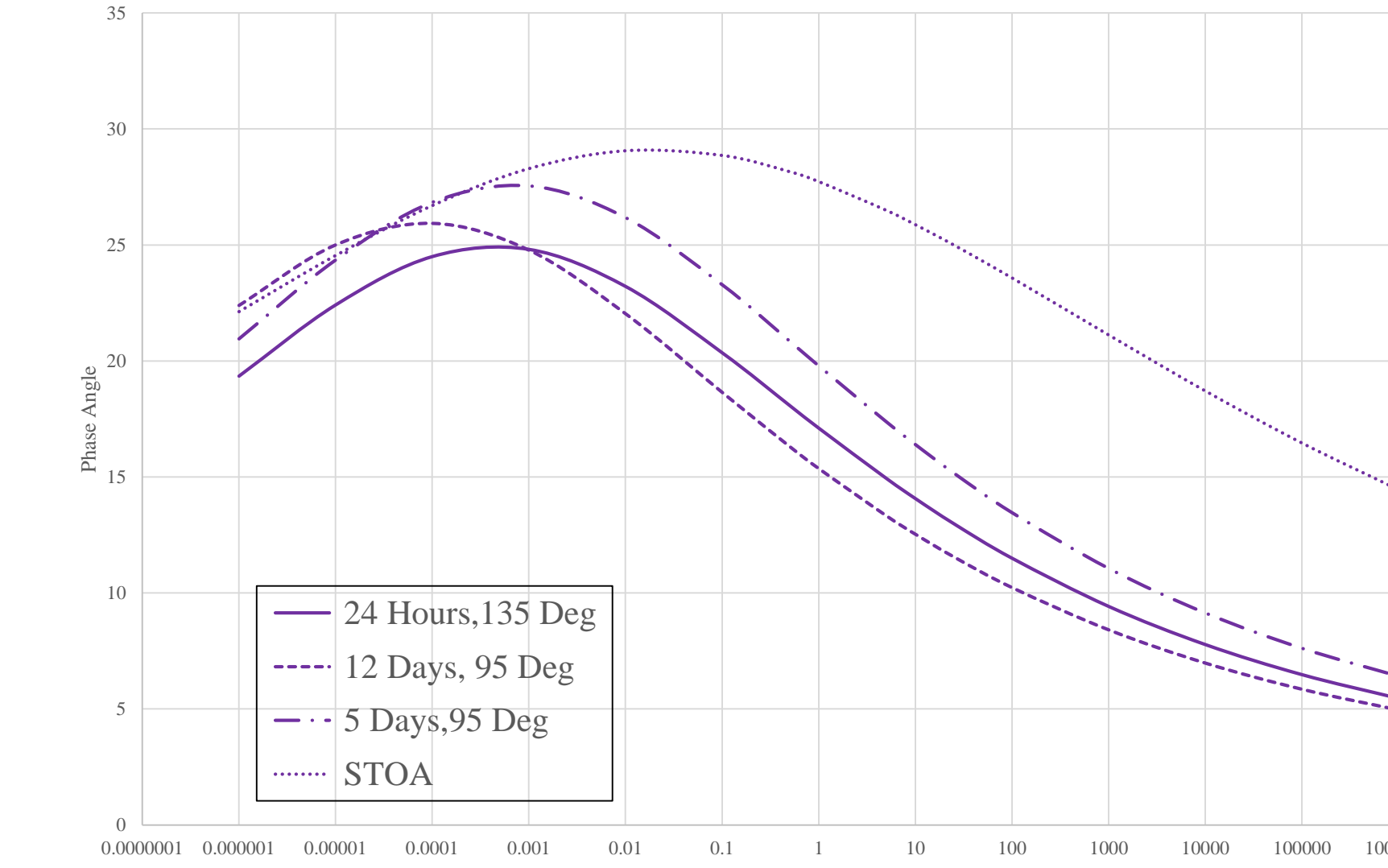PG 58-28,12.5, RAPRAS (Dynamic Modulus)

PG 58-28,12.5 RAPRAS (Phase Angle)

PG 52-34,19,RAPRAS (Dynamic Modulus)

PG 52-34,19,RAPRAS (Phase Angle)

Discussion

Different Binders

- Two T-Tests were considered statistically significant for both E* and δ (5 Days, 95 Deg)
- All T-Tests for E* were considered statistically significant.
- The difference between E* and δ is greater for STOA and 5 Day aging than 12 Day and 24 Hour LTOA mixtures.

Different Aggregate

- Three T-Tests were considered statistically significant for both E* and δ (PG 58-28 12.5 vs 19→ 24 Hours, 12 Days and 5 Days)
- The values for E* of 19 mm mixture are higher than the values of 12.5 mm mixture.
- STOA→ Smaller values for E* and larger values for δ

Different Aging Level

- Several T-Tests were considered statistically significant
  1.) 52-34,12.5 mm → 24 Hours vs. 5 Days and STOA, 12 Days vs. 5 Days and STOA
  2.) 58-28, 19 mm → 24 Hours vs. 12 Days, 5 Days and STOA, 12 Days vs 5 Days and STOA, 5 Days vs. STOA
  3.) 52-34, 19 mm → 24 Hours vs. 5 Days and STOA, 12 Days vs. 5 Days and STOA, 5 Days vs. STOA

Conclusion/Summary

Essential Question: How do properties of viscoelastic material (E* and δ) change with different aging levels?
  1.) 24 Hours and 12 Days seem to follow same trend.
  2.) 5 Days and STOA seem to have been effected the most (Lower E* and Higher δ)

References

Ali, Yasir, et al. "Investigation of Factors Affecting Dynamic Modulus and Phase Angle of Various Asphalt Concrete Mixtures." *Materials and Structures*, vol. 49, no. 3, 2015, pp. 857–868., doi:10.1617/s11527-015-0544-3

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Acknowledgements