Simple Tests for Detecting Poor Cracking Resistant Binders

Research Team

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Acknowledgement and disclaimer

- This research is funded by the Texas Department of Transportation. The views, thoughts, and opinions presented here belong solely to the presenter, and not necessarily to any organization.

- This research is a jointed effort between TTI and UT-Austin. Both research teams play a significant role to the overall research project.

Presentation outline

- Introduction and objective
- Overall research methodology
- Laboratory experimental design
  - Selection of typical asphalt binders
  - Asphalt binder tests and parameters
  - Asphalt mixture tests and parameters
- Laboratory test results and analysis
- Summary and recommendation

Introduction

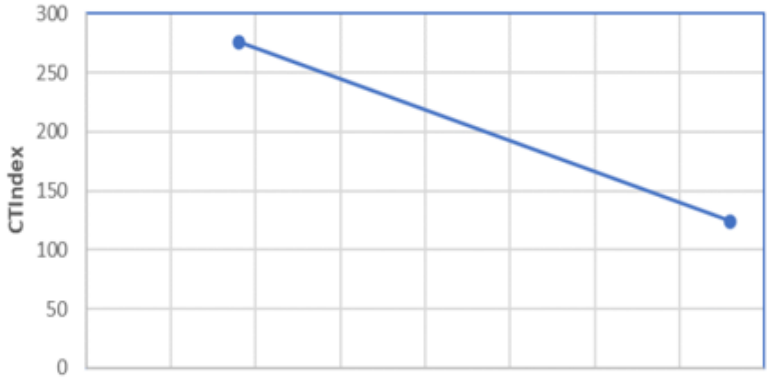
- Mix durability or cracking is the predominant problem in Texas.



- Binder grade, content, and quality are three critical factors.
  - *Binder grade selection guide* addressing the binder grade selection
  - *Balanced mix design* mainly dealing with the binder content
  - Urgent need of rapid tests detecting binder quality

Introduction

- Binder quality issue:
  - Phil Blankenship et al. AAPT 1998: "Are all PG70-22S the same?
  - TxDOT had design/production issue with varying binder source change.



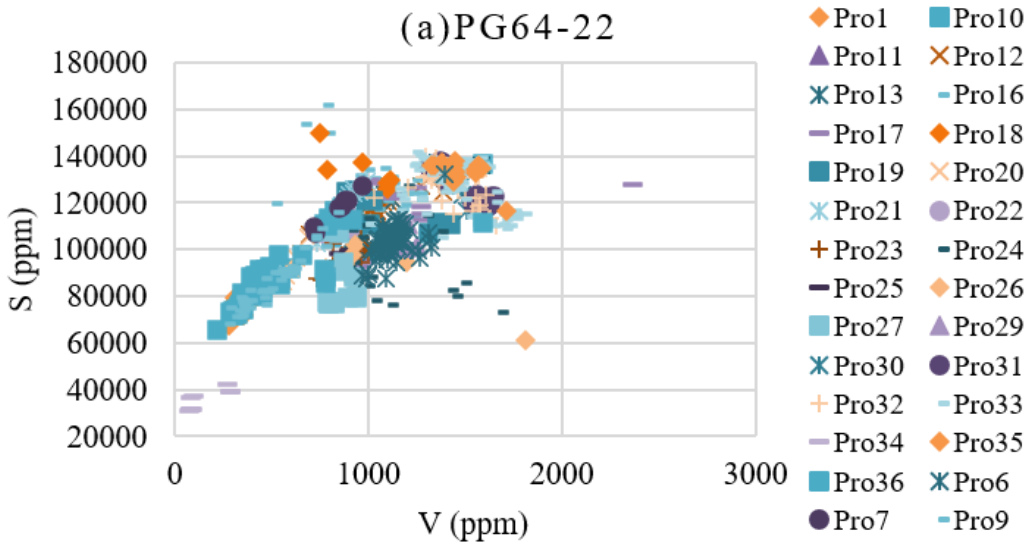
- Objective:
  - Identify suitable tests and parameters for detecting poor cracking resistant binders

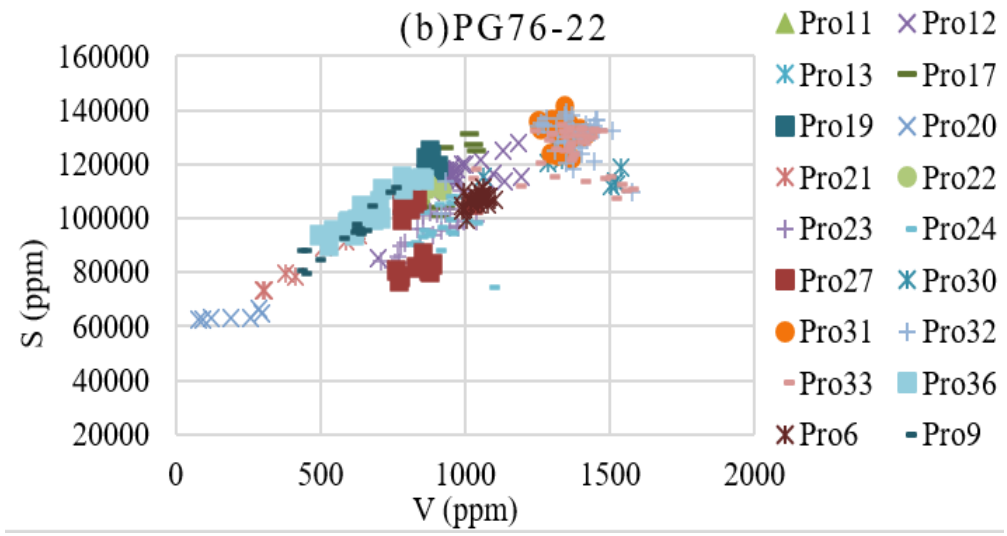
Overall research methodology

- Review literature to identify potential binder tests
- Laboratory study to select 2-3 binder tests and parameters
  - Select representative binders
  - Perform binder tests
  - Perform mixture tests
  - Compare binder data with mixture data
  - Identify the best binder tests and parameters
- Construct field test sections to validate binder tests and parameters

Laboratory experimental design

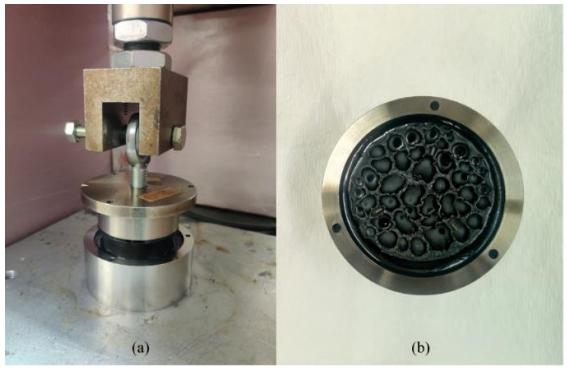
- Binder selection:
  - PG64-22:8 sources; PG76-22: 6 sources





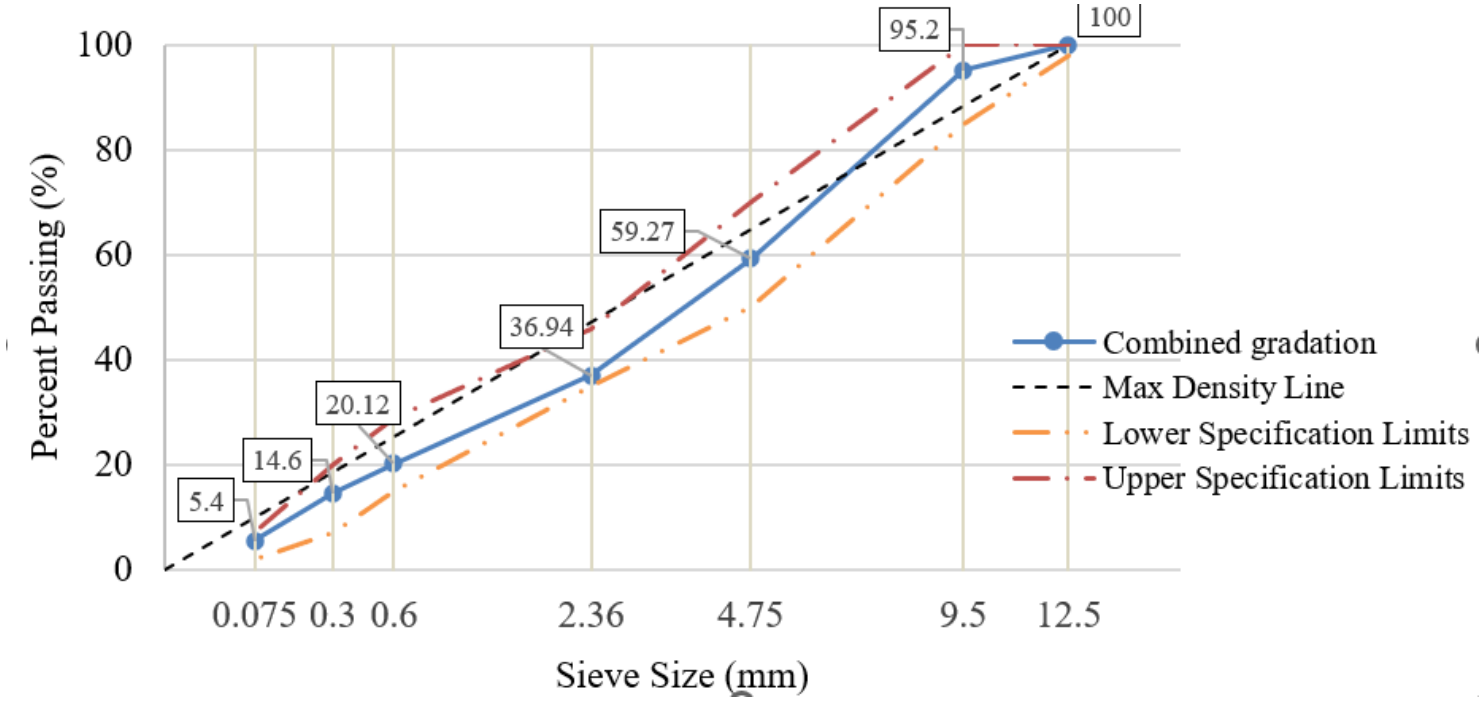
Laboratory experimental design

- Binder tests:
  - binder chemistry: XRF
  - Binder failure:
    - Poker chip test
  - Poker chip creep test
  - Traditional binder rheology tests: DSR and BBR
    - R-value
    - ΔTc
    - Phase angle (e.g. $\delta_{8967\ \mathrm{kPa}}$)
    - NCHRP 9-59 Glover-Rowe parameter: $\frac{G^*(cos\delta)^2}{sin\delta}$



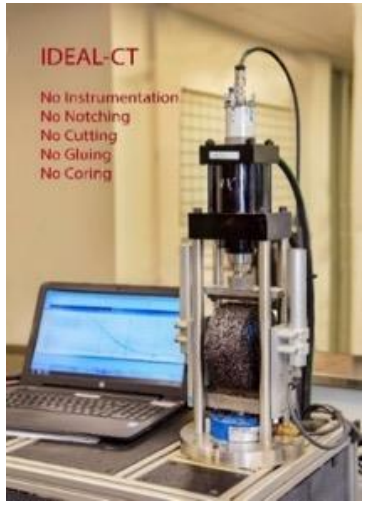
Laboratory experimental design

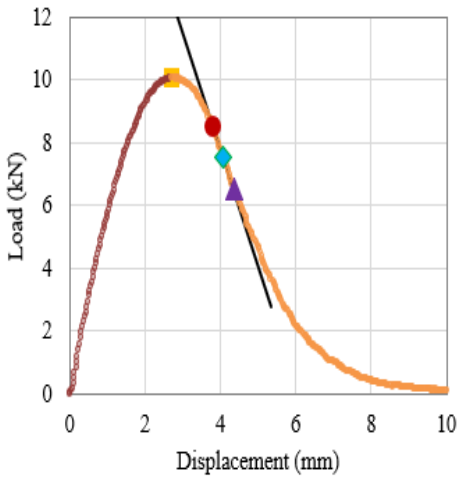
- Asphalt mixtures
  - One virgin mix with 5.5%AC, only variable: asphalt binder source

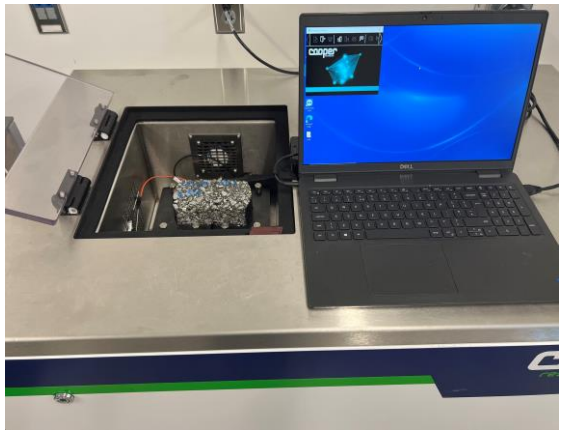


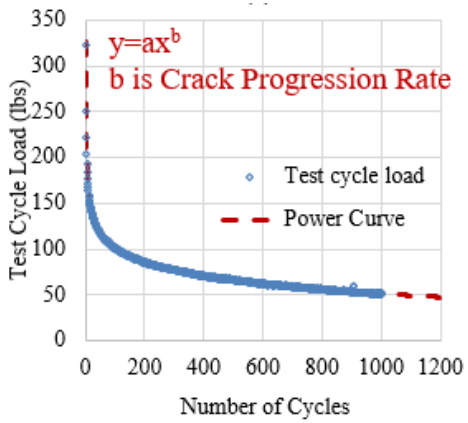
Laboratory experimental design

- Mixture tests and parameters:
  - Mix aging levels:
    - short-(2hr@comp. temp) ≈ Binder RTFO; long-term (20hr@110C)≈binder PAV20
  - Two cracking tests: IDEAL-CT and OT



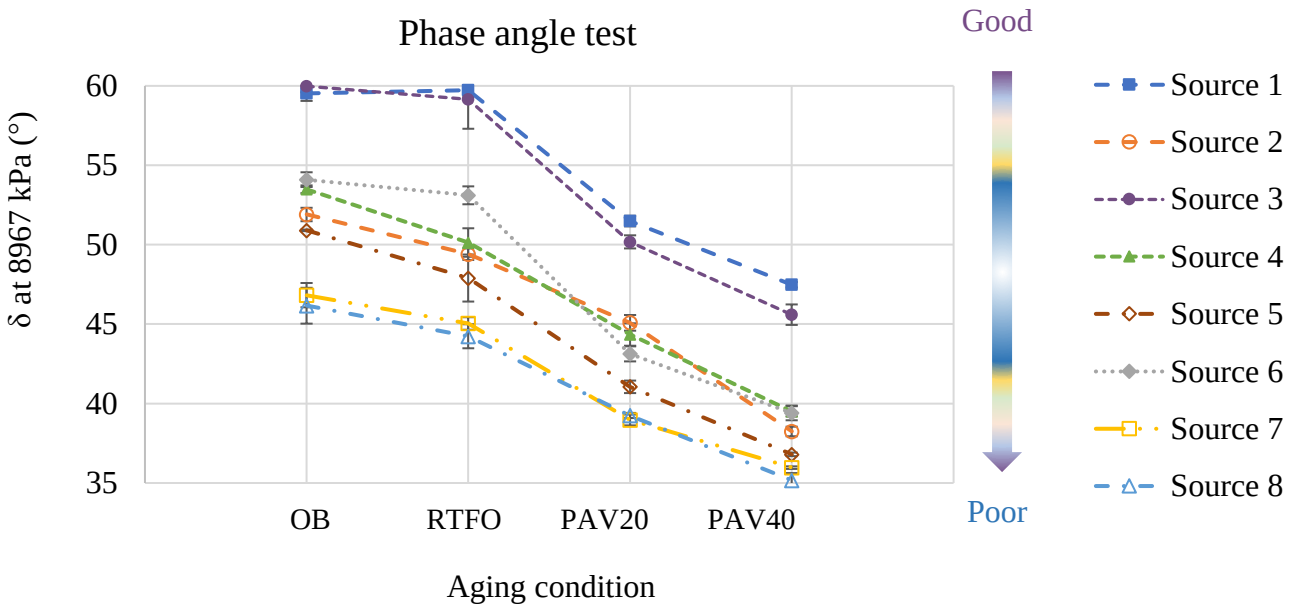


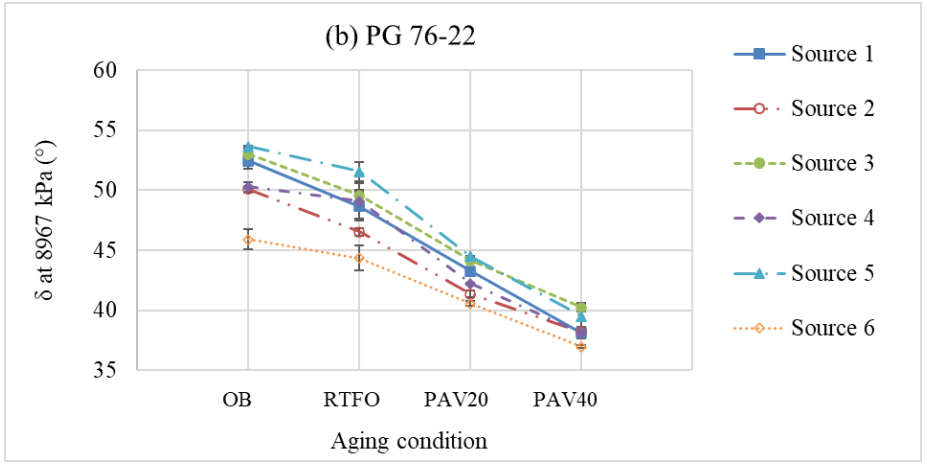




Laboratory test results

- Binder rheology parameter: Phase angle at 8967 kPa

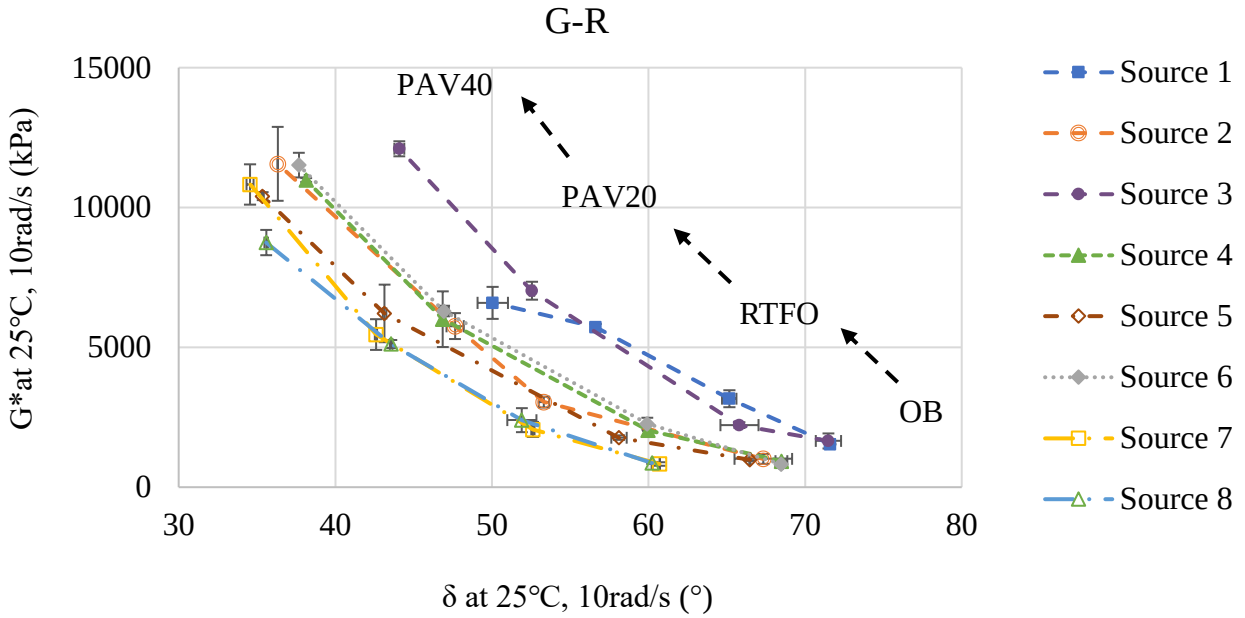


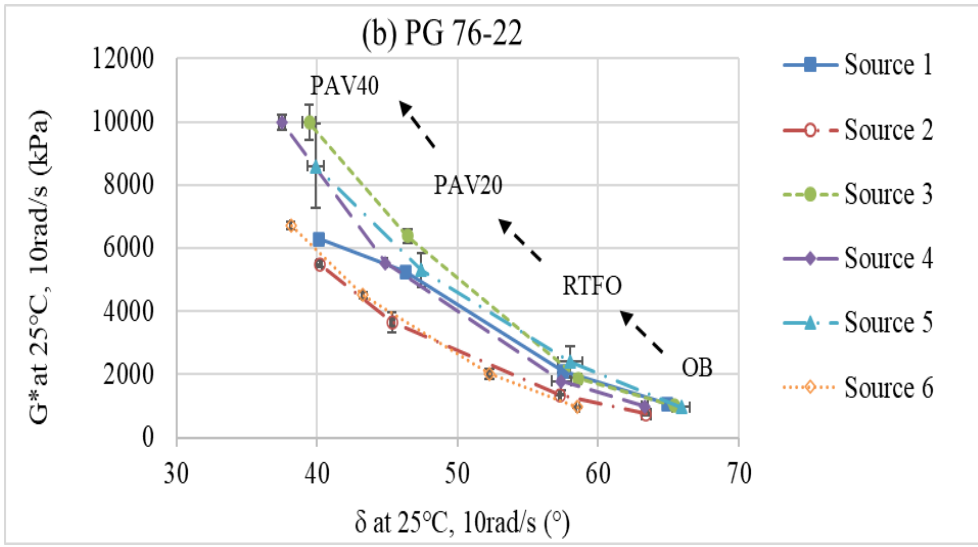


$$\delta_{8967\ \text{kPa}} = \delta_1 + \frac{log(8967) - log(|G^*|_1)}{(|G^*|_2) - (|G^*|_1)}(\delta_2 - \delta_1)$$

Laboratory test results

- Binder rheology parameter: G* and phase angle@25C

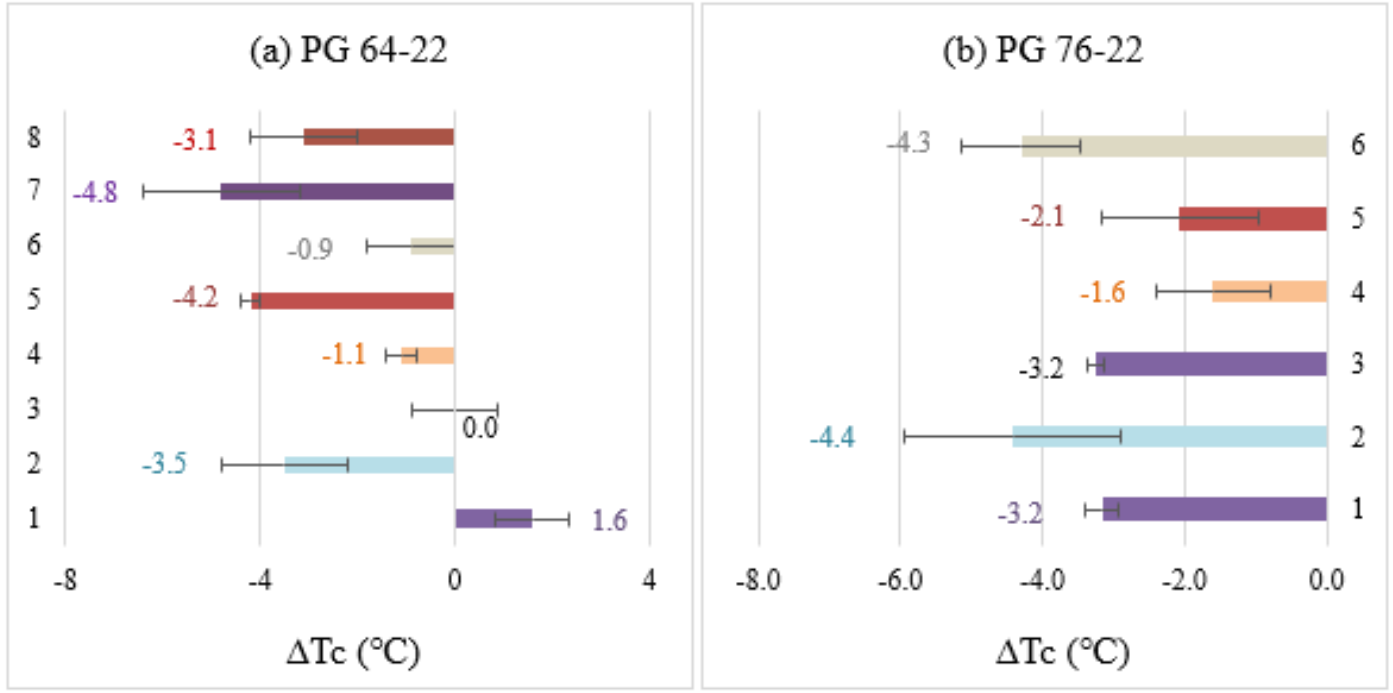




$$G - R = \frac{G^*(cos\delta)^2}{sin\delta}$$

Laboratory test results

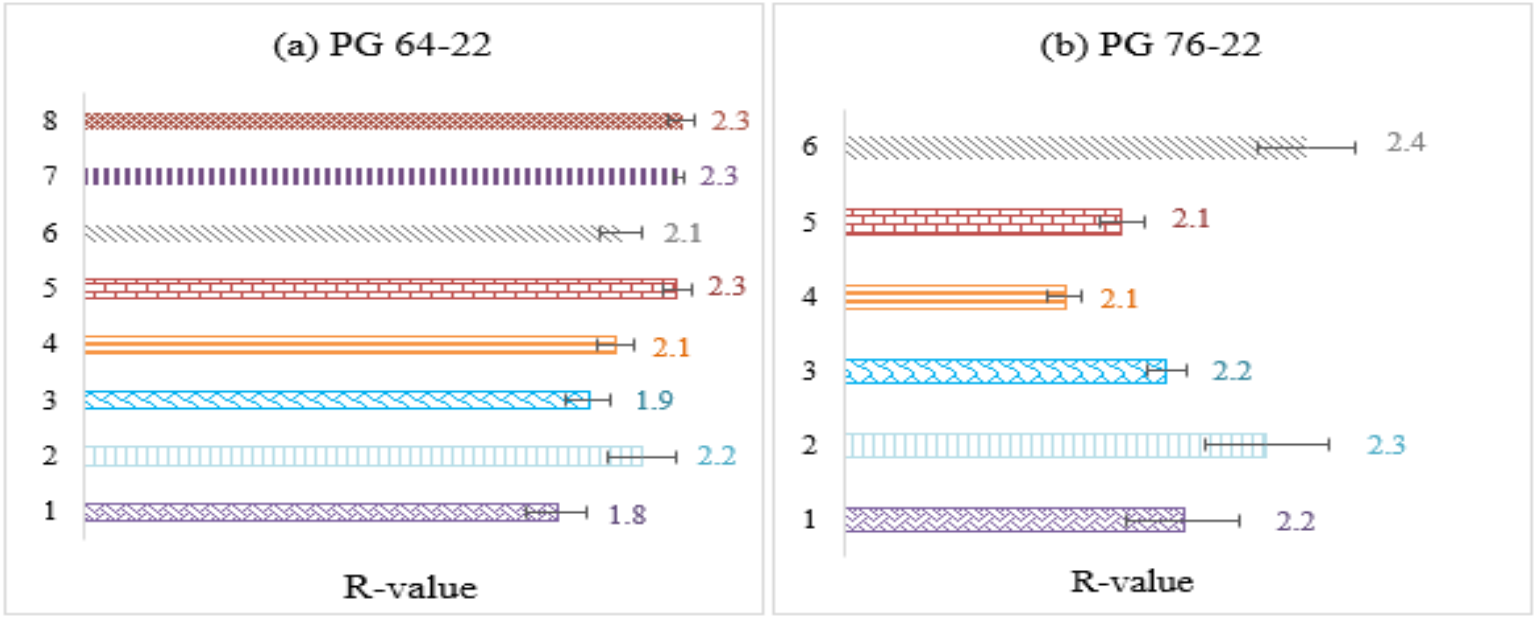
- Binder rheology parameter: ΔTc from BBR



$$\Delta T_c = T_{c,s} - T_{c,m}$$

Laboratory test results

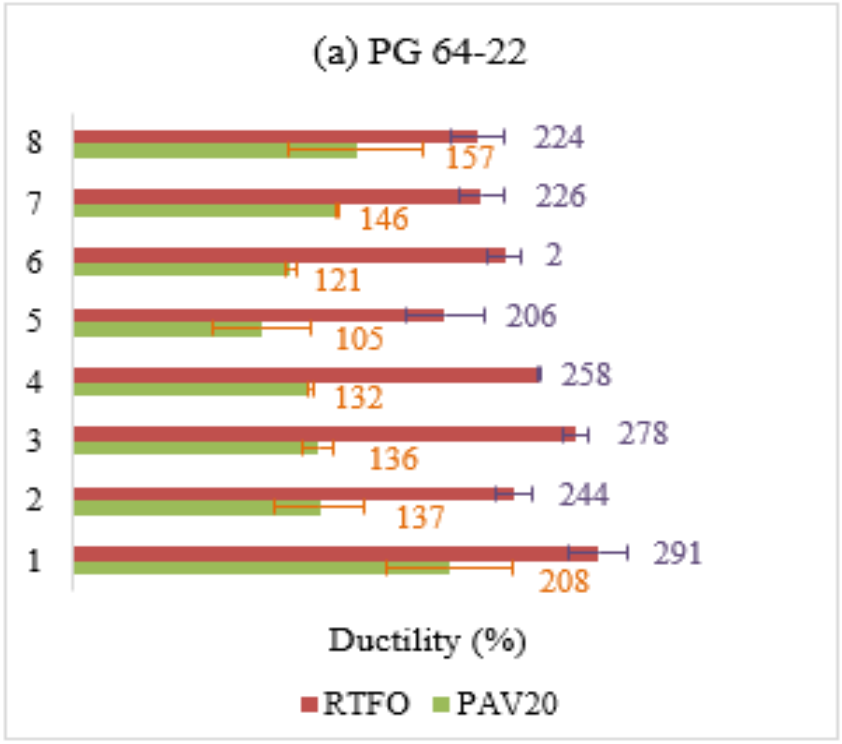
- Binder rheology parameter: R-value from BBR

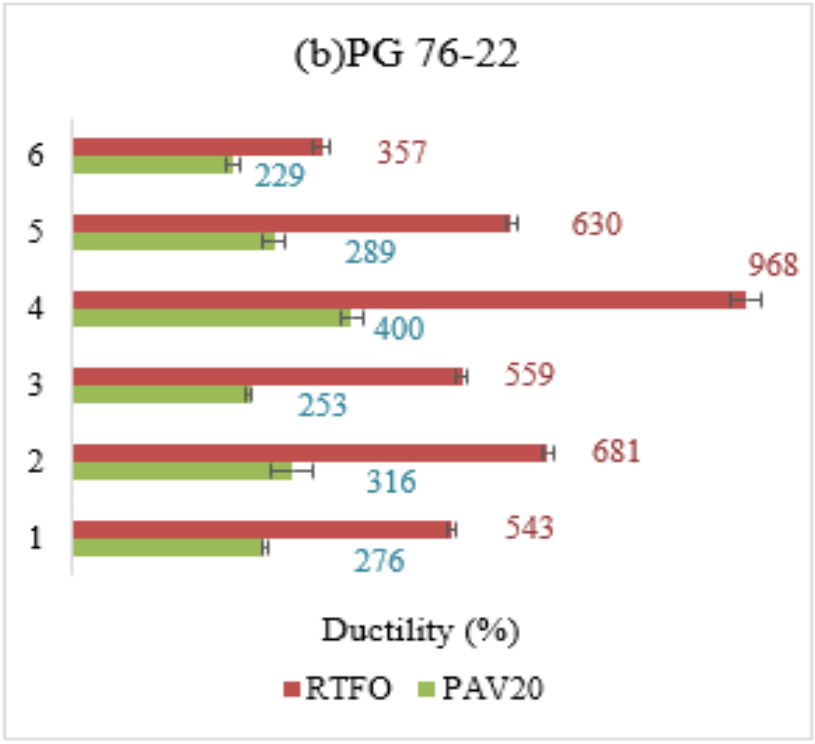


$$R = \log(2)\frac{\log(S/3000)}{\log(1-\mathrm{m})}$$

Laboratory test results

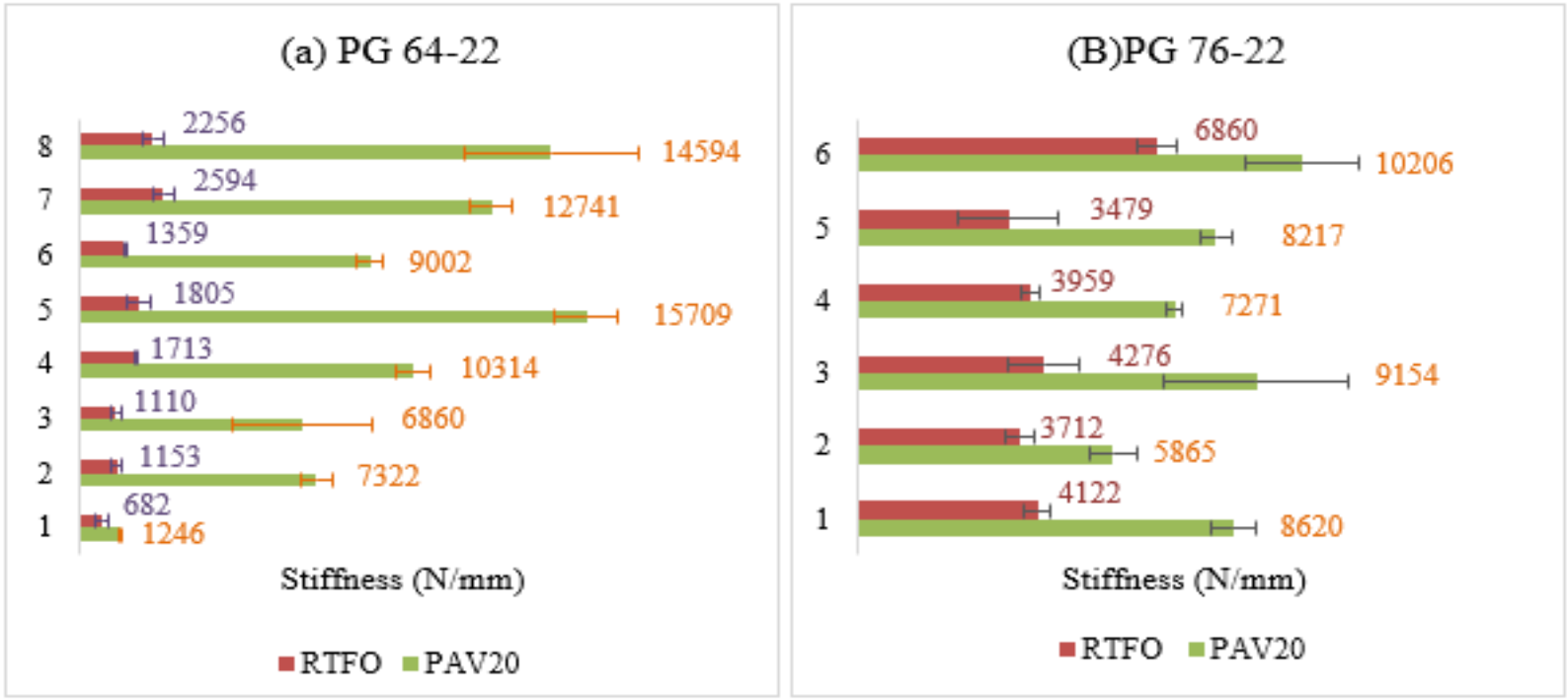
- Poker chip test results





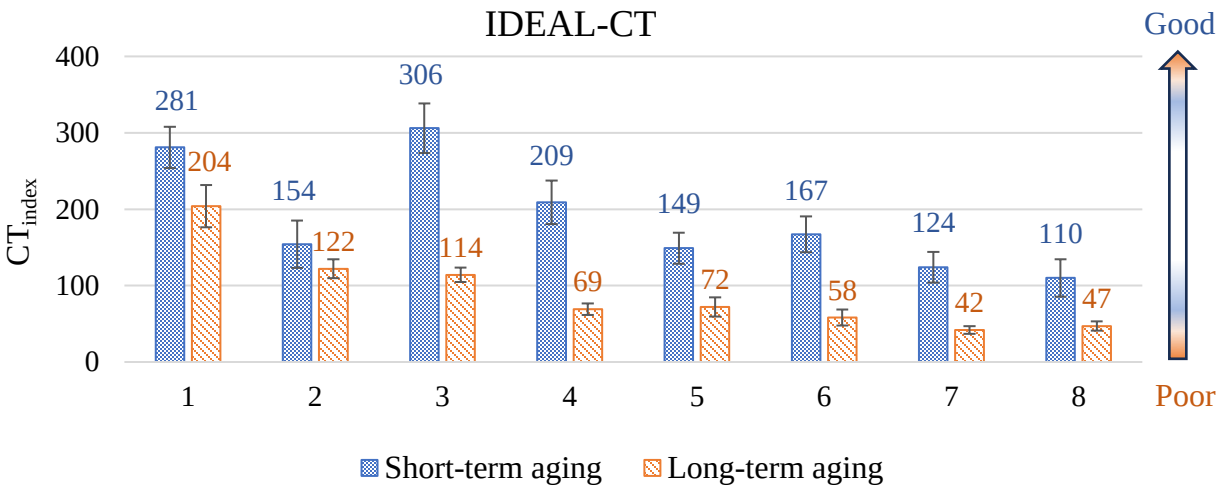
Laboratory test results

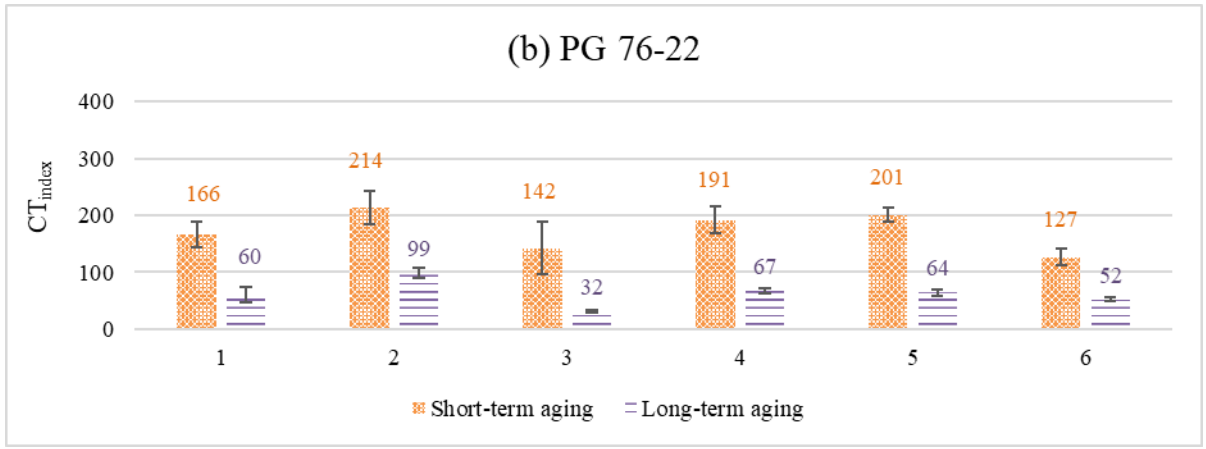
- Poker chip creep test results



Laboratory test results

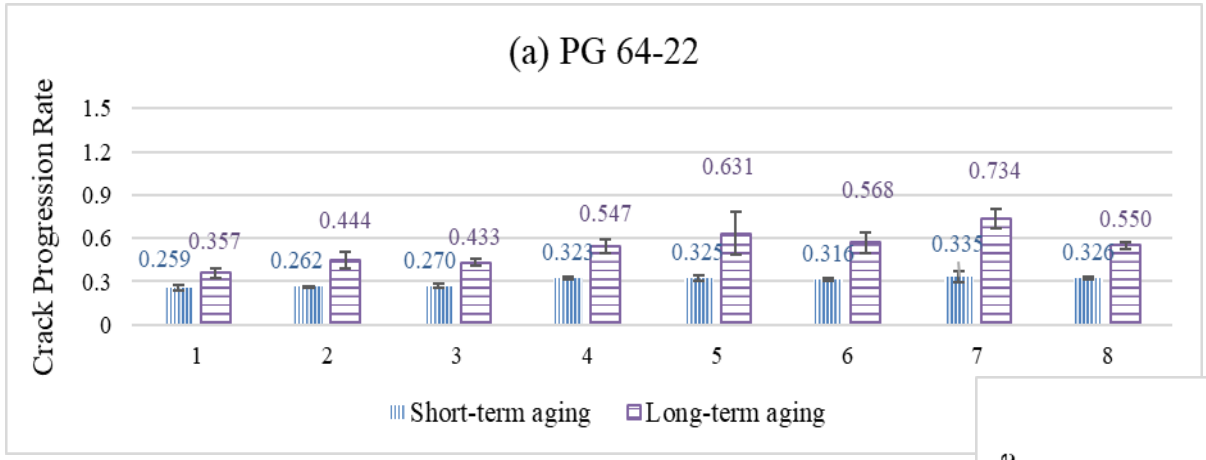
- Mixture test results: IDEAL-CT

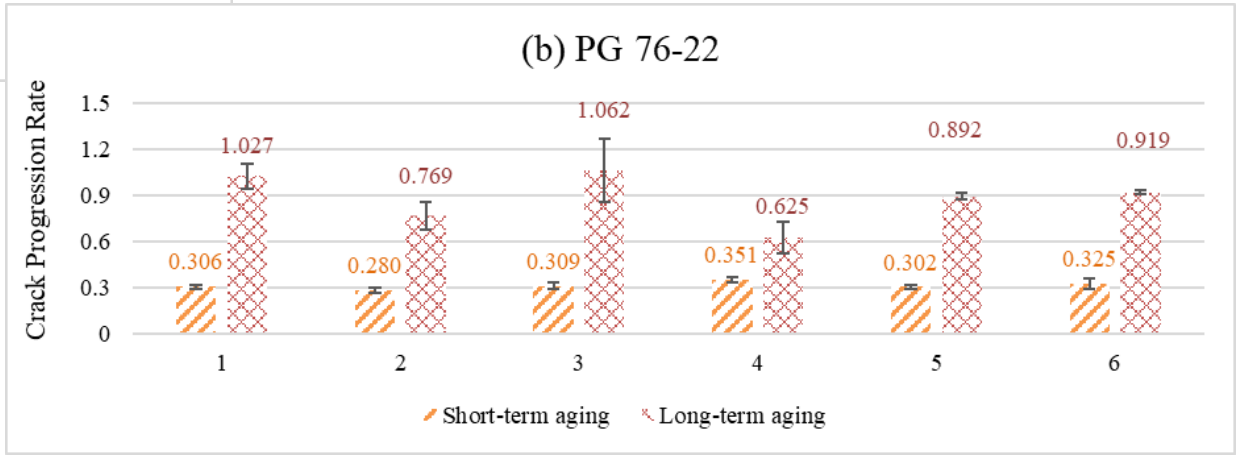




Laboratory test results

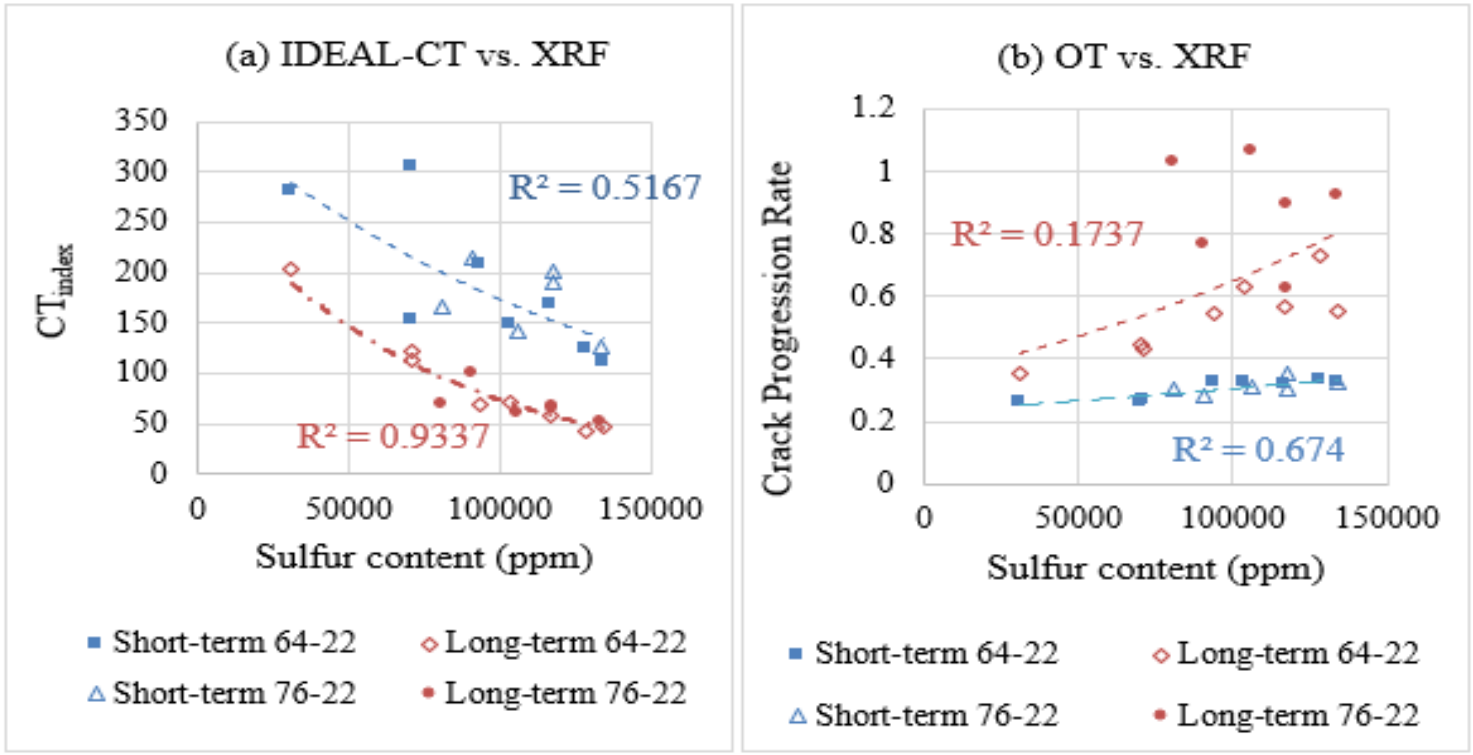
- Mixture test results: OT





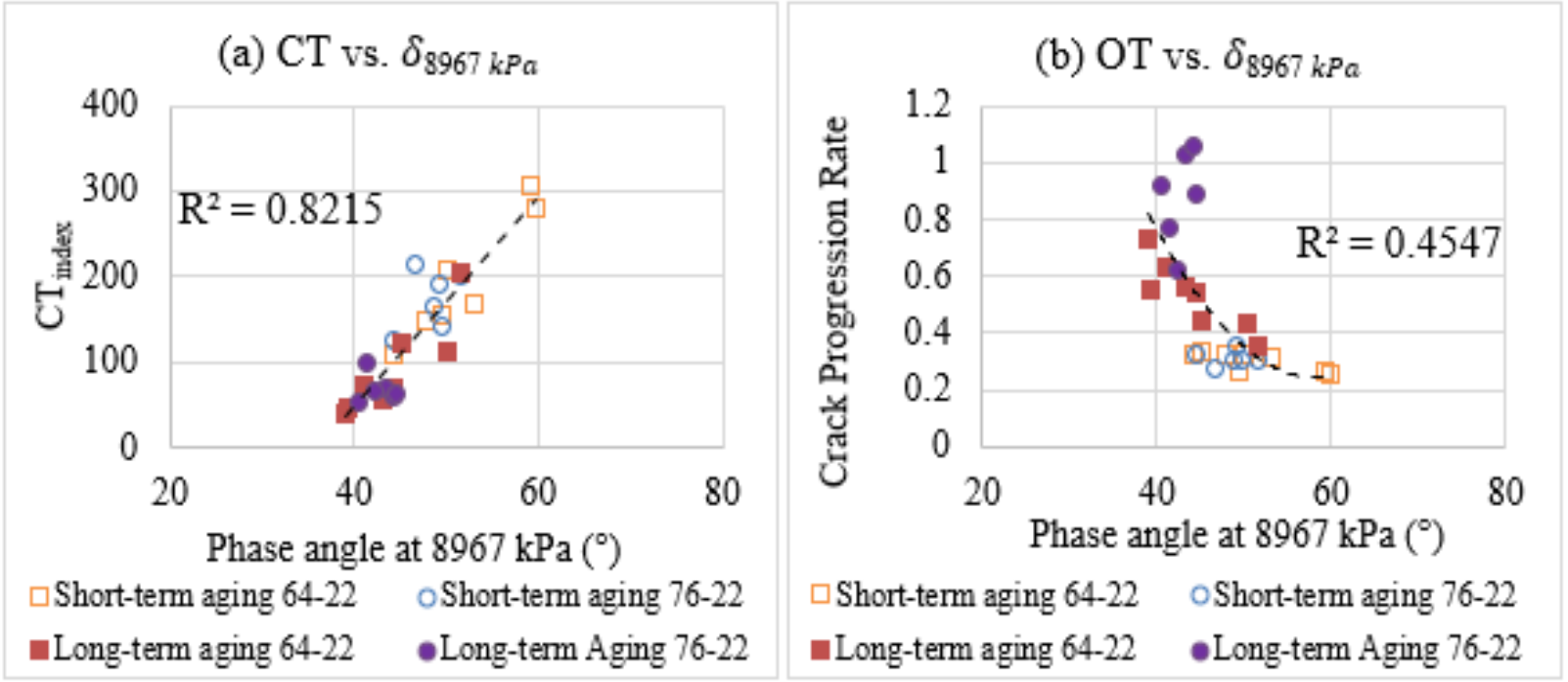
Test results analysis

- Correlation between XRF-sulfur content and mixture parameters



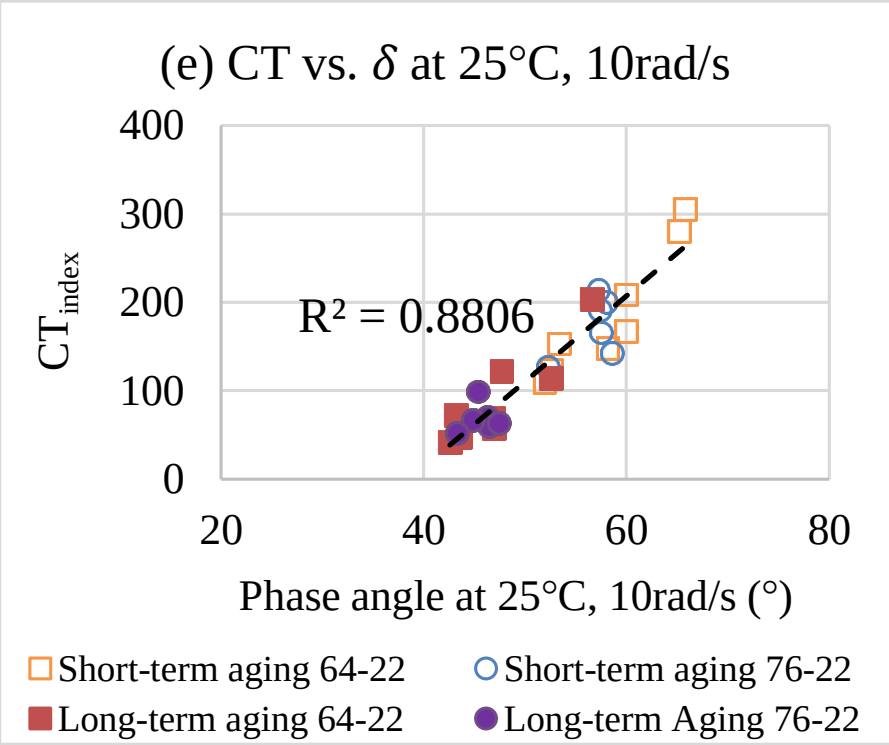
Test results analysis

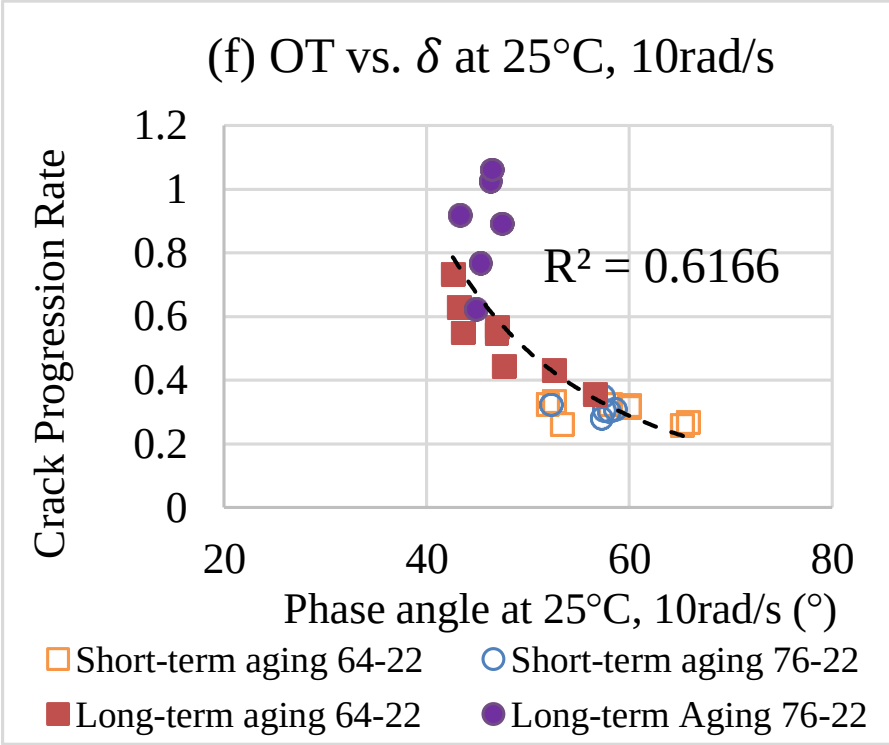
- Correlation between δ at 8967 kPa and mixture parameters



Test results analysis

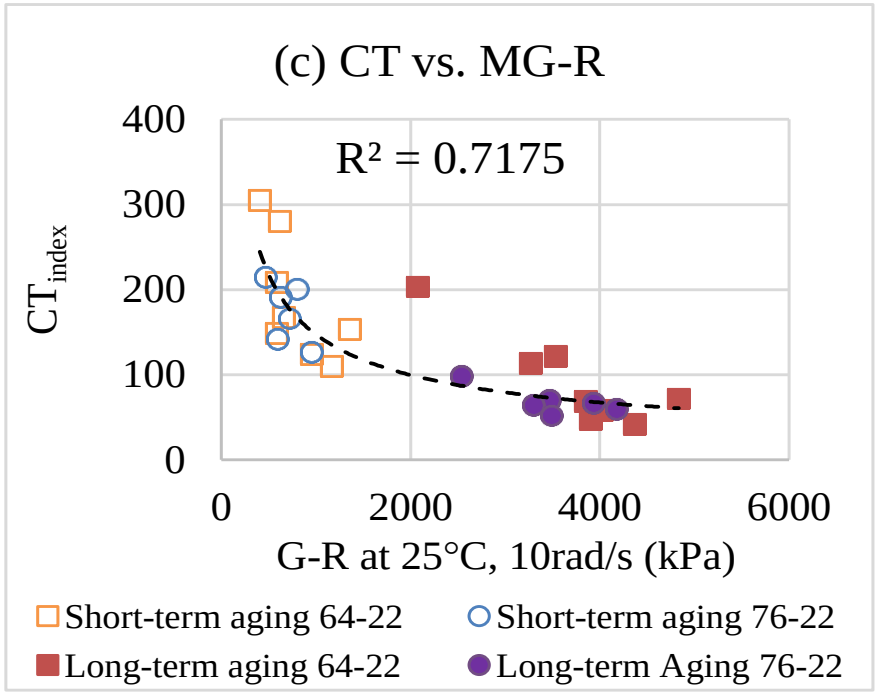
- Correlation between phase angle at 25C and mixture parameters

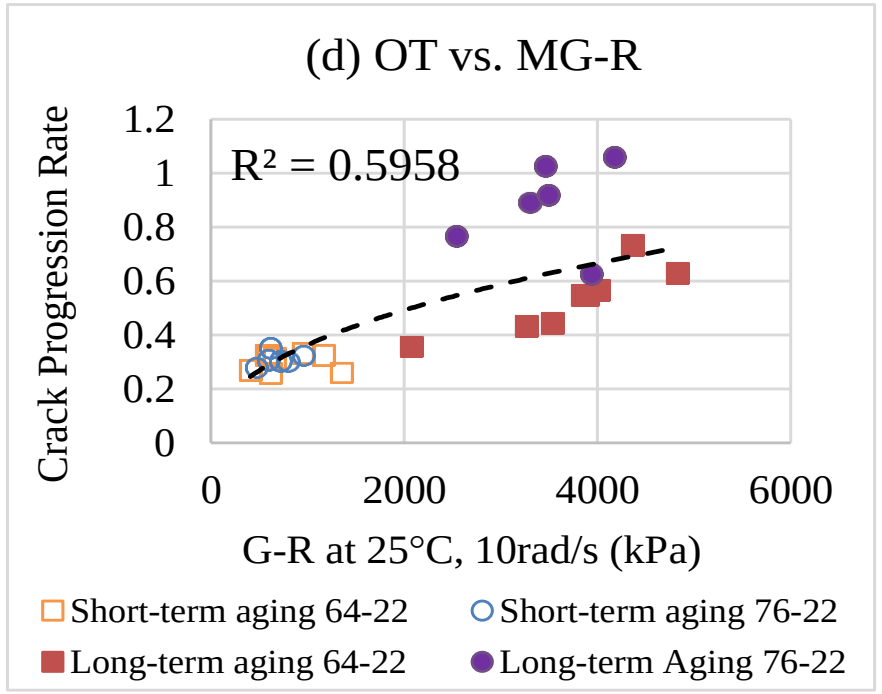




Test results analysis

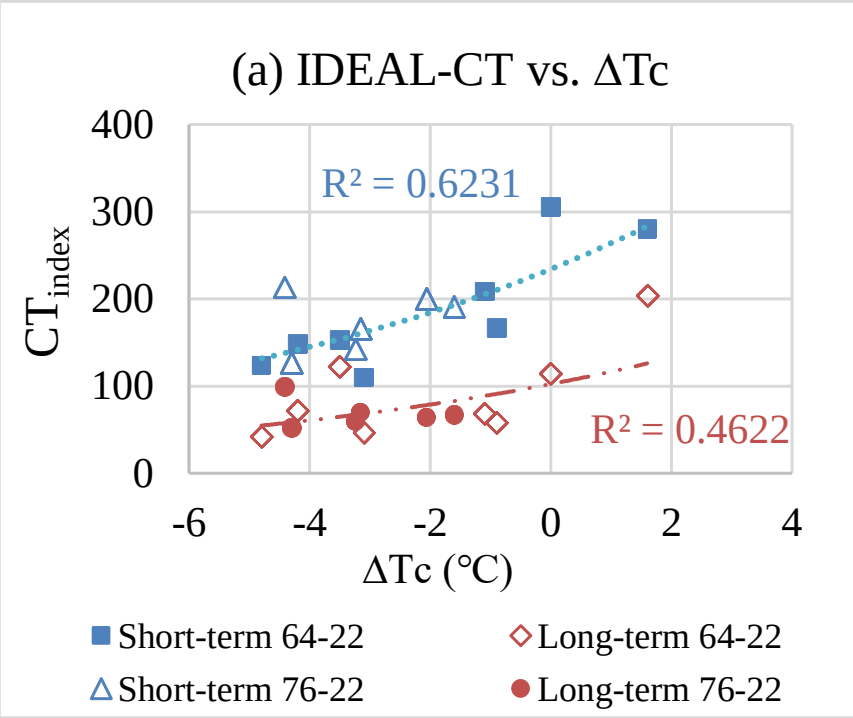
- Correlation between G-R and mixture parameters

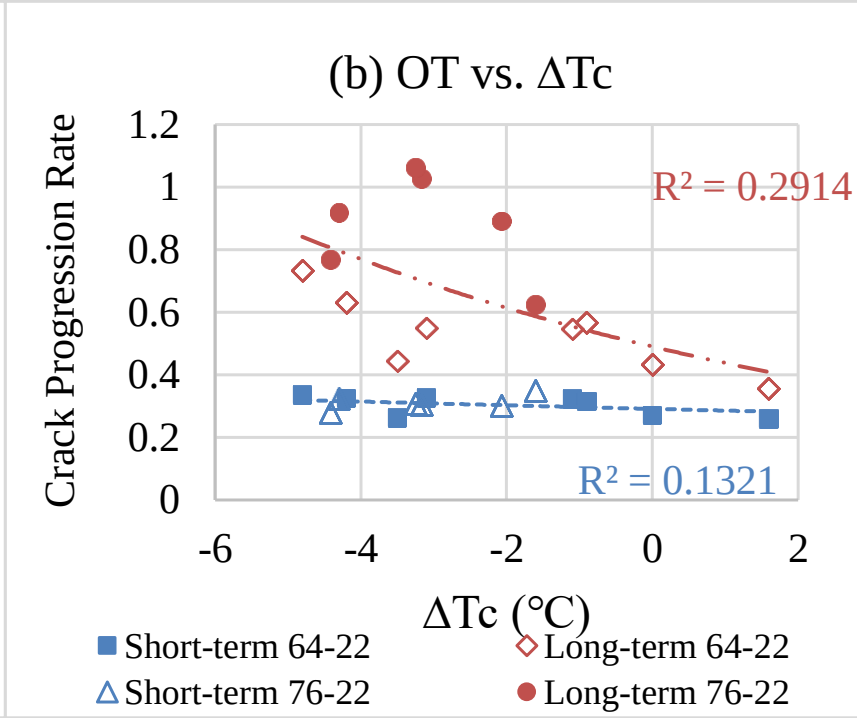




Test results analysis

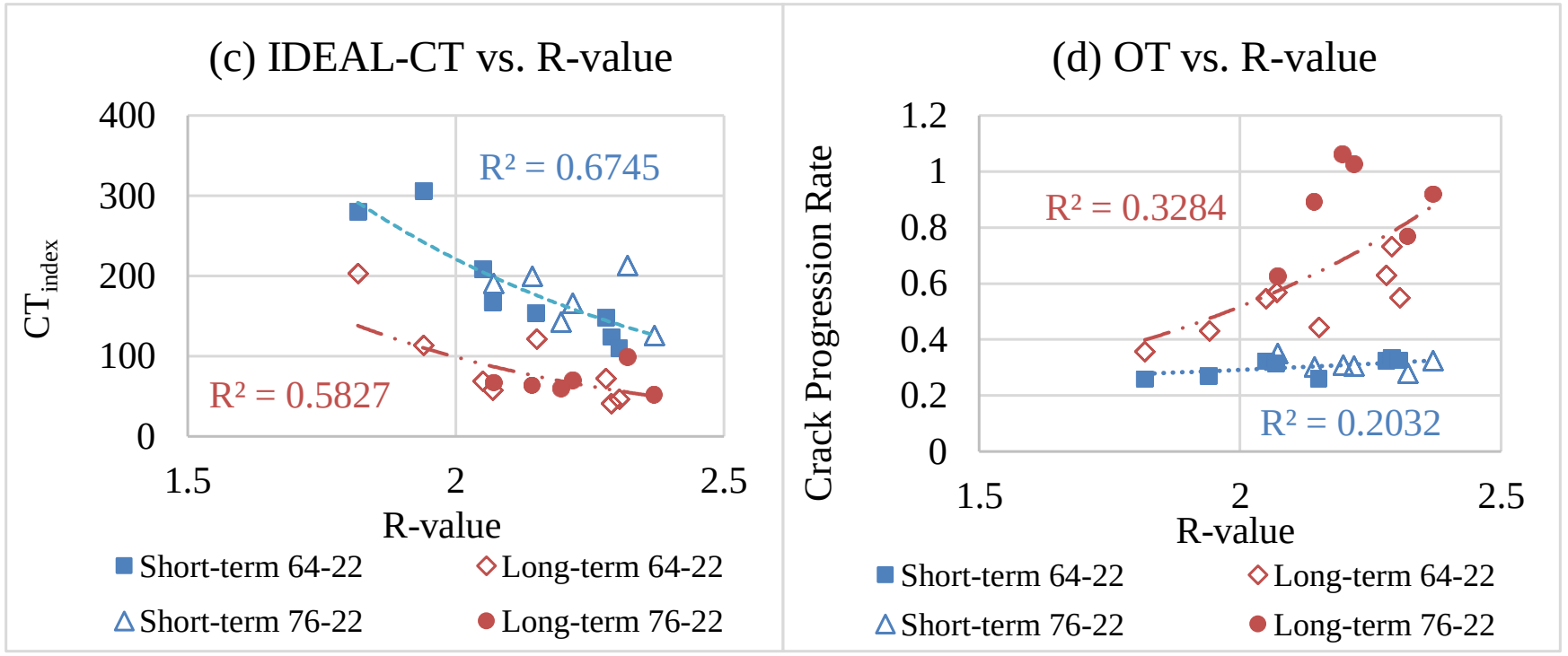
- Correlation between ΔT_c and mixture parameters





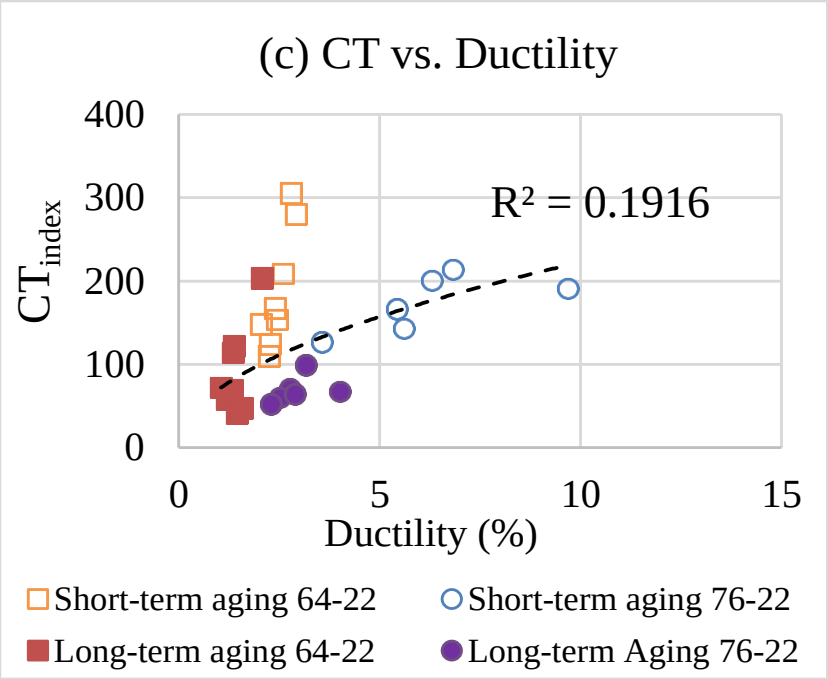
Test results analysis

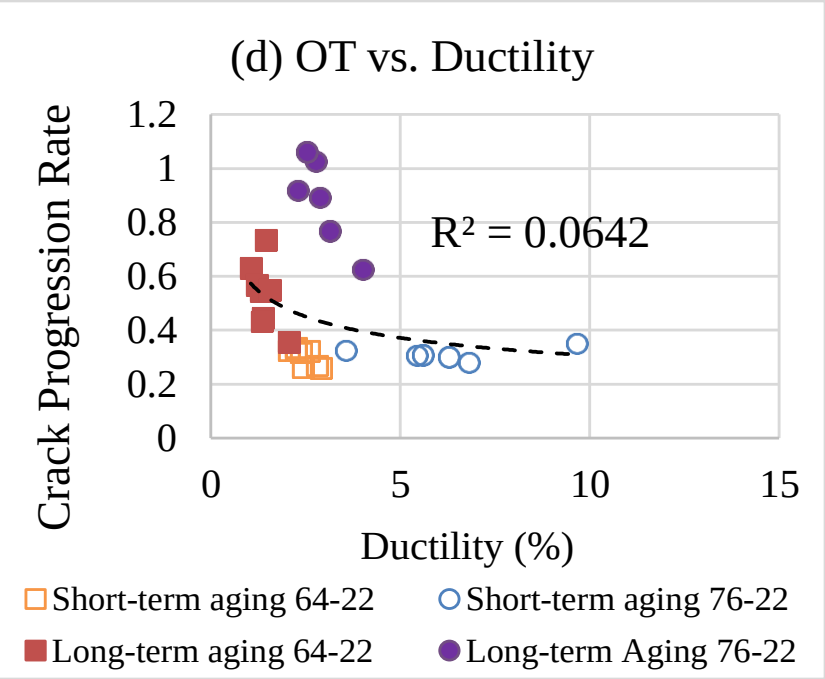
- Correlation between R-value and mixture parameters



Test results analysis

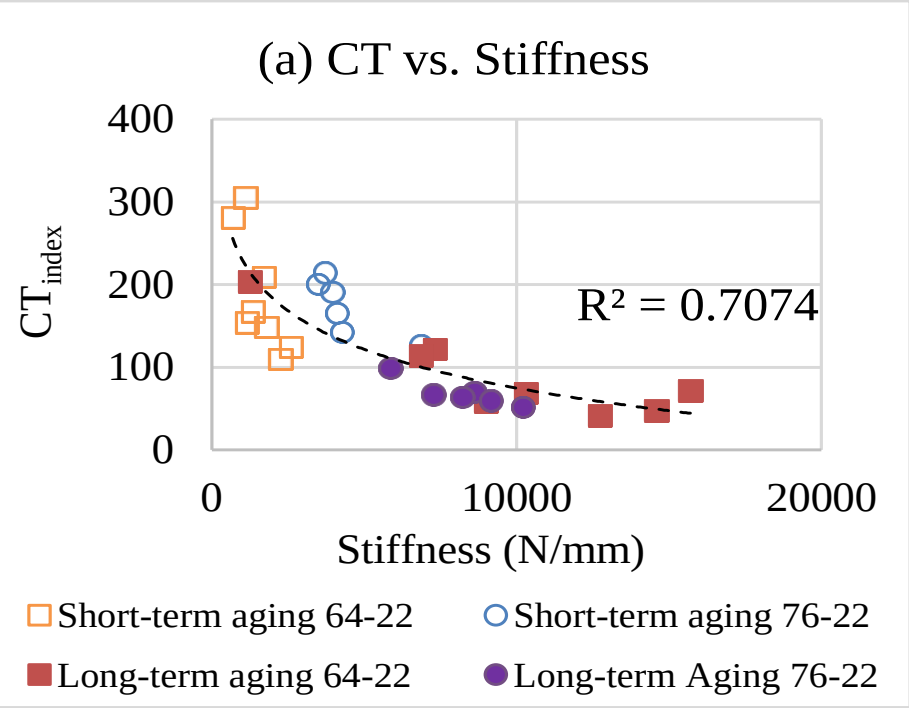
- Correlation between poker chip ductility and mixture parameters

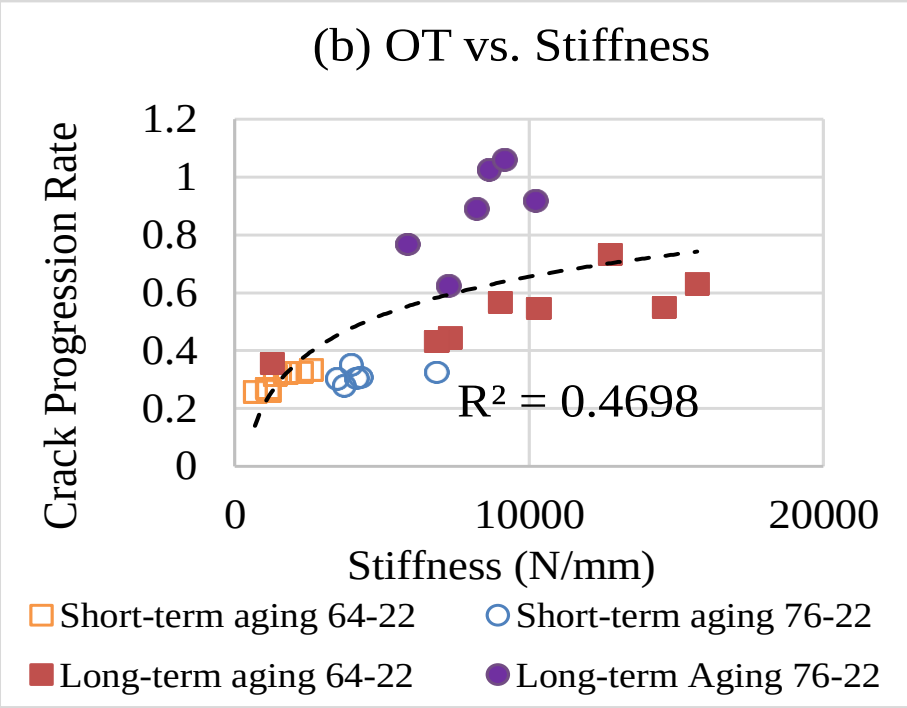




Test results analysis

- Correlation between poker chip stiffness and mixture parameters





Summary and recommendation

- Summary
  - Phase angle at 25C has the best correlation with mixture parameters
  - Phase angle at G*=8967 kPa has the 2nd best correlation with mixture parameters
  - Poker chip stiffness has the 3rd best correlation with mixture parameters

- Recommendation
  - Construct field test sections to validate these binder parameters.

Q/A

Thank You All!