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Viscoelastic Modeling and Uncertainty Analysis of Asphalt Mixtures in Colorado

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Introduction

- Dynamic modulus (DM) is a key material property for long-term pavement performance prediction
- Several mathematical models are proposed in literature which allow determination of viscoelastic properties of asphalt mixtures beyond the laboratory testing conditions
- This study assesses DM data using viscoelastic models and performs uncertainty analysis to improve pavement design accuracy

Background

- Colorado DOT uses pavement mechanistic-empirical design (PMED) and the uncertainty in dynamic modulus modeling can affect accurate pavement performance predictions, which in turn can affect pavement design
- The DM data is obtained from CDOT Report 2020-02 is grouped based on aggregate gradations and binder types (see Table 1)

Table 1. Eleven mixture groups used in this study

Mix ID	NMAS (in.)	Binder
S(100) PG 64-22	0.75	PG 64-22
S(100) PG 76-28	0.75	PG 76-28
SMA PG 76-28	0.50	PG 76-28
SX(75) PG 58-28	0.50	PG 58-28
SX(75) PG 58-34	0.50	PG 58-34
SX(75) PG 64-22	0.50	PG 64-22
SX(75) PG 64-28	0.50	PG 64-28
SX(100) PG 58-28	0.50	PG 58-28
SX(100) PG 64-22	0.50	PG 64-22
SX(100) PG 64-28	0.50	PG 64-28
SX(100) PG 76-28	0.50	PG 76-28

Viscoelastic Modeling

- **2S2P1D Phenomenological Model**

$$|E^*(i\omega\tau)| = E_{\infty 2S2P1D} + \frac{E_{02S2P1D} - E_{\infty 2S2P1D}}{1+\delta\left(i\omega\tau_{2S2P1D}\right)^{-k} + \left(i\omega\tau_{2S2P1D}\right)^{-h} + \left(i\omega\beta_{2S2P1D}\tau_{2S2P1D}\right)^{-1}}$$

- **Sigmoidal Model**

$$\log|E^*| = a + \frac{b}{1+e^{-(d+g\cdot\log(f_{red}))}}$$

- **Modified CAM Model**

$$|E^*(\omega)| = E_e + \frac{E_g - E_e}{\left[1+\left(\frac{\omega_{CE}}{\omega}\right)^{\frac{\log 2}{R_E}}\right]^{\frac{w\cdot R_E}{\log 2}}}$$

- **Havriliak-Negami (HN) Model**

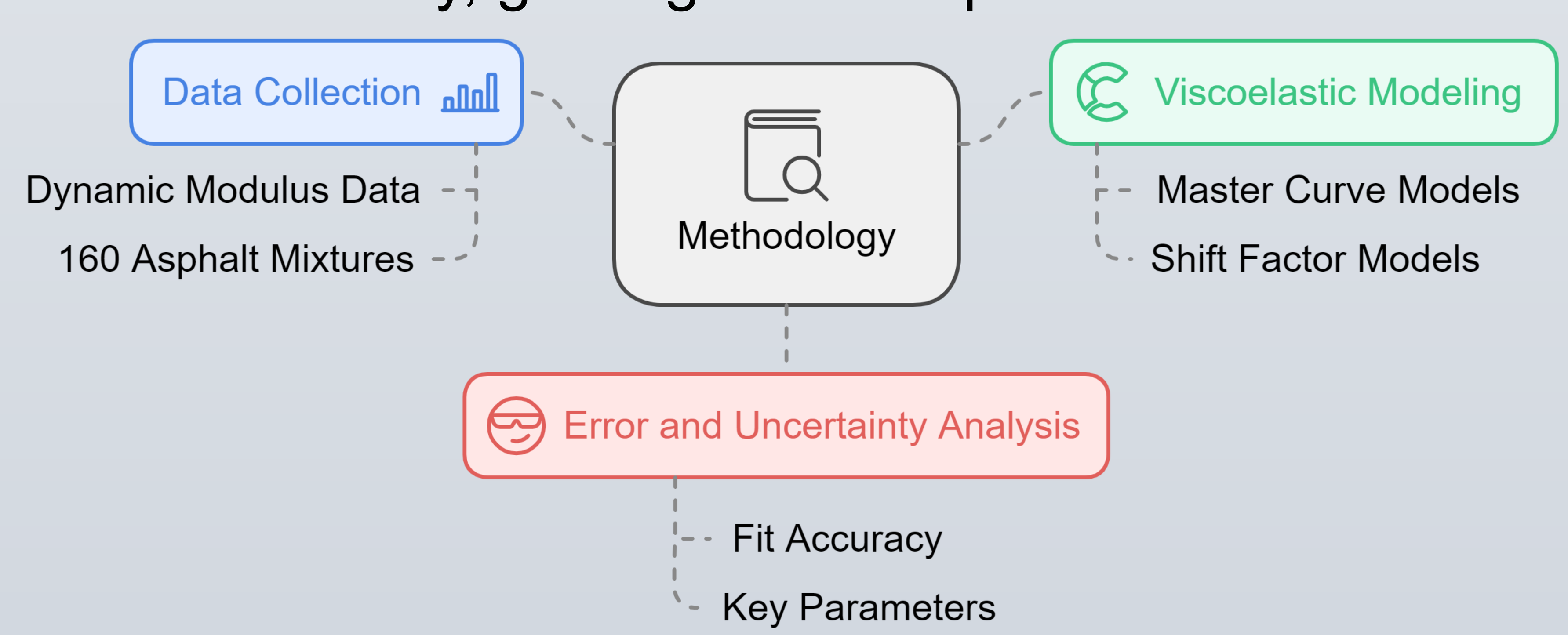
$$|E^*(\omega)| = E_{\infty HN} + \frac{E_{0HN} - E_{\infty HN}}{\left[1+\left(i\omega\tau_{HN}\right)^{\alpha}\right]^{\beta_{HN}}}$$

Shift Factor Models

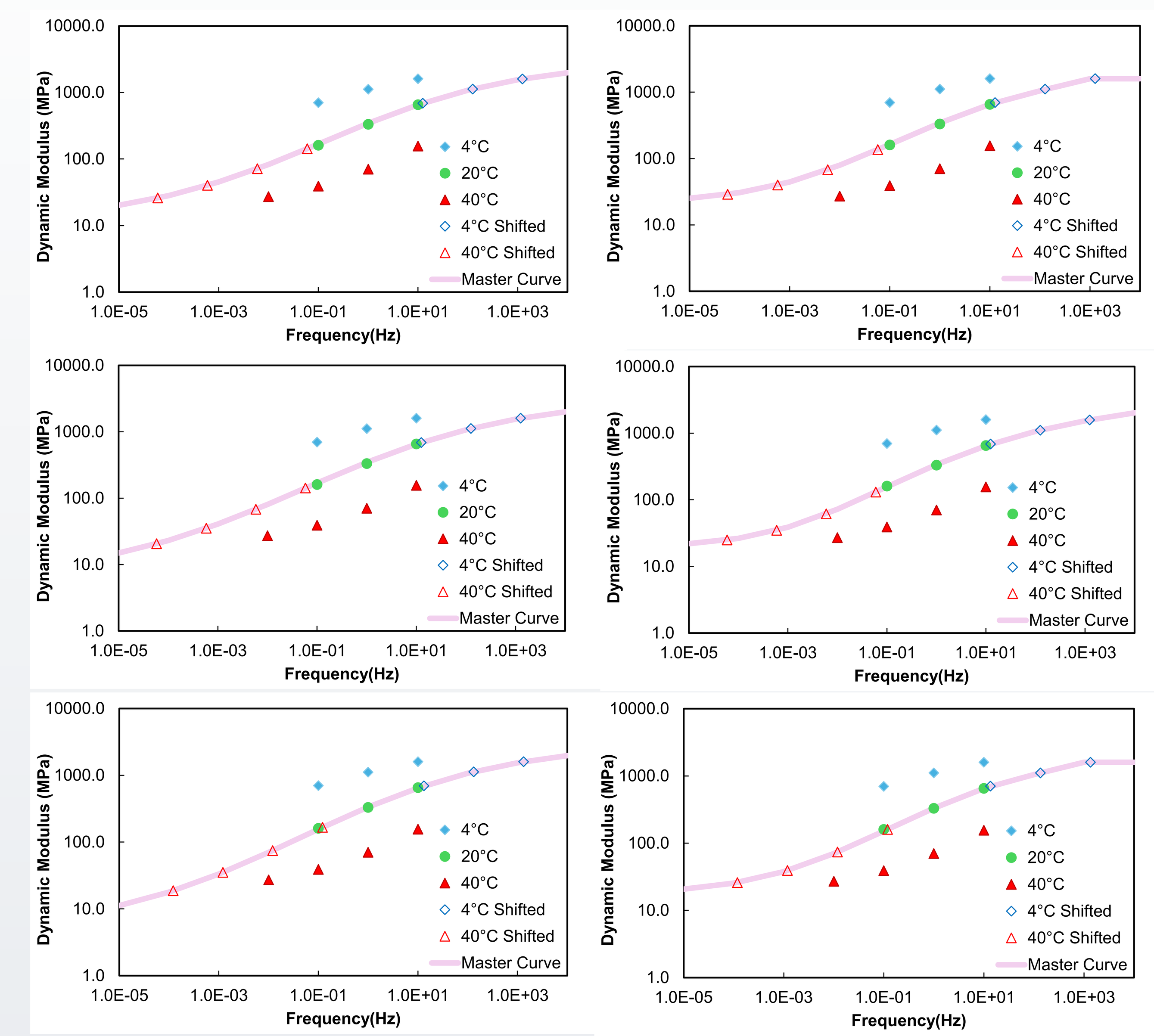
- WLF Equation
- Second order polynomial function
- Arrhenius Equation
- Modified Arrhenius Equation

Methodology

- **Data Collection:** Dynamic modulus data collected for a total of 160 asphalt mixtures across Colorado
- **Viscoelastic modeling:** Using a total of sixteen combinations of master curve and shift factor models
- **Error and Uncertainty Analysis:** Error analysis to evaluate fit accuracy and identify key parameters that affect model reliability, guiding future improvements



Analysis and Results



Dynamic moduli for different combinations of master curve models and shift factor models

Future Work

- Impact of error minimization methods on master curve fitting will be evaluated
- Impact of dynamic modulus uncertainty on pavement performance using AASHTOware Pavement-ME software will be assessed
- Critical evaluation of master curve model parameters and their role in error propagation

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MAPS MENTORING, ACCESS, AND PLATFORMS IN STEM

CDOT

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