Damage Assessment of Existing Asphalt Pavements for Mechanistic-Empirical Rehabilitation Design in Virginia: a Hybrid Approach

By:

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Presentation Outline

- Introduction
- Problem Statement
- Objectives and Scope of Work
- Experimental Plan
- MEPDG Approach
- HYBRID Approach
- Pavement Rehabilitation Analysis
- Summary of Findings, Conclusions, & Recommendations

Introduction

- Many State Highway Agencies are currently in the process of implementing Pavement ME to design their flexible pavements.
- VDOT implemented Pavement ME for the design of new construction and reconstruction projects.
- Currently, on-going research is evaluating the use of Pavement ME for the design of rehabilitated flexible pavements in Virginia.

Introduction *(Cont'd)*

Pavement ME Hierarchical System:

- ***Level 1:*** most implementable procedure available; involves comprehensive laboratory and / or field tests.
- ***Level 2:*** inputs estimated through correlations with other material properties that are measured in the laboratory and / or the field.
- ***Level 3:*** estimates the most appropriate design input value of the material property based on experience with little or no testing.

Problem Statement

- Major step in the rehabilitation design using Pavement ME is the ***damage assessment*** in the existing AC pavement.

- Damage is computed as function of ***undamaged dynamic modulus*** (Witczak model) and ***damaged dynamic modulus*** (FWD Testing).

→ **Potential of damage overestimation !!!**

Problem Statement *(Cont'd)*

- ***Limitations of the Pavement ME software:***

→ The ***Witczak model*** is mandated for the estimation of ***undamaged dynamic modulus*** of the existing layer.

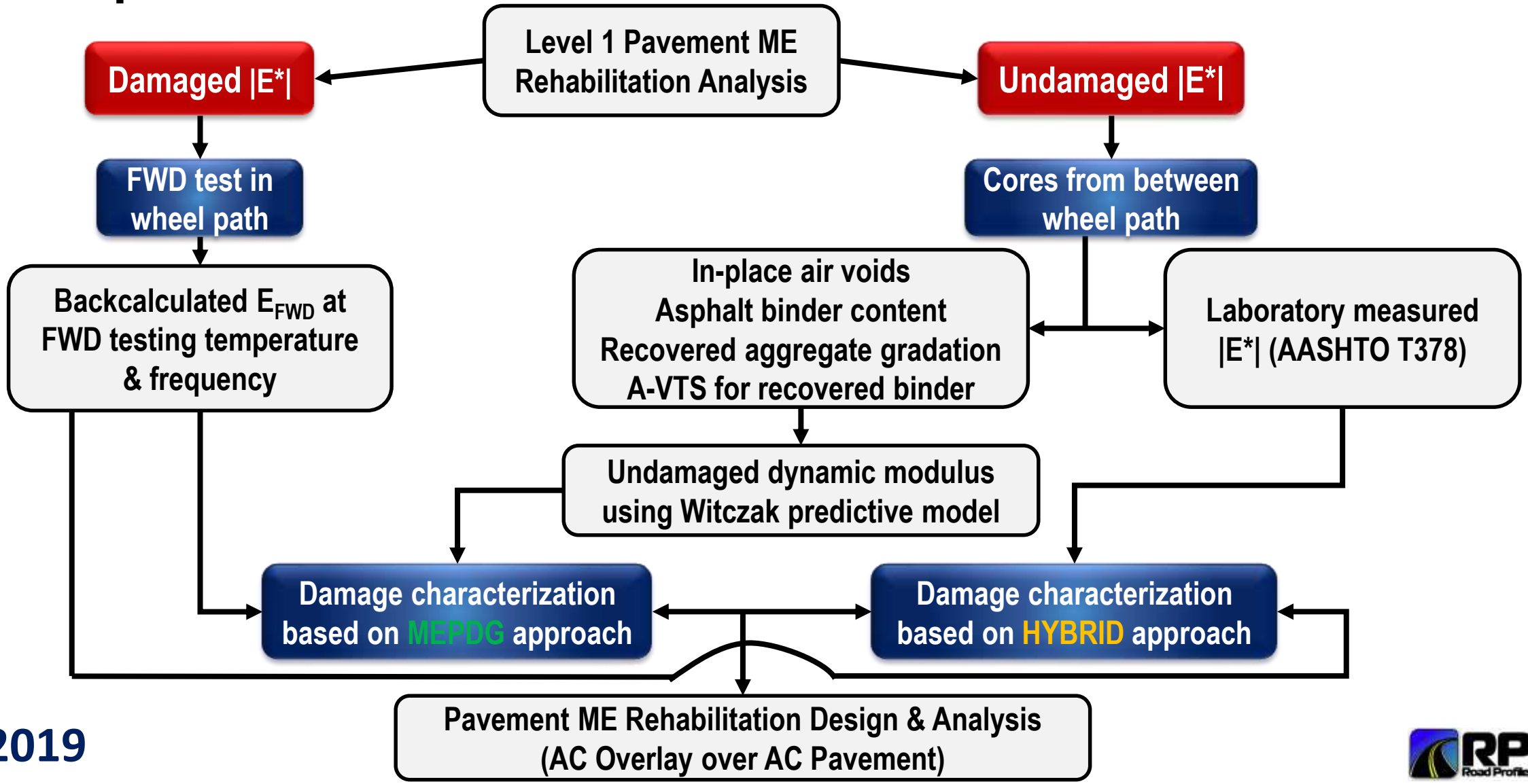
→ The regression constants for the Witczak prediction model cannot be modified in the current version of the software.

Objectives and Scope of Work

- Assess the use of Level 1 analysis for M-E rehabilitation designs of deteriorated AC pavements in Virginia.

- Explore the possible implementation of a ***HYBRID*** approach for AC damage characterization to overcome the challenges of using Witczak prediction model.

Experimental Plan



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Case Study: Route 60

- From Red Rd (Rt 630E/W), Buckingham County to White Pine Ln, Cumberland County (L=5.42 mi)
- Two-way AADTT = 176 trucks
- Two lanes: 1 lane in design direction
- Operational speed = 55 mph

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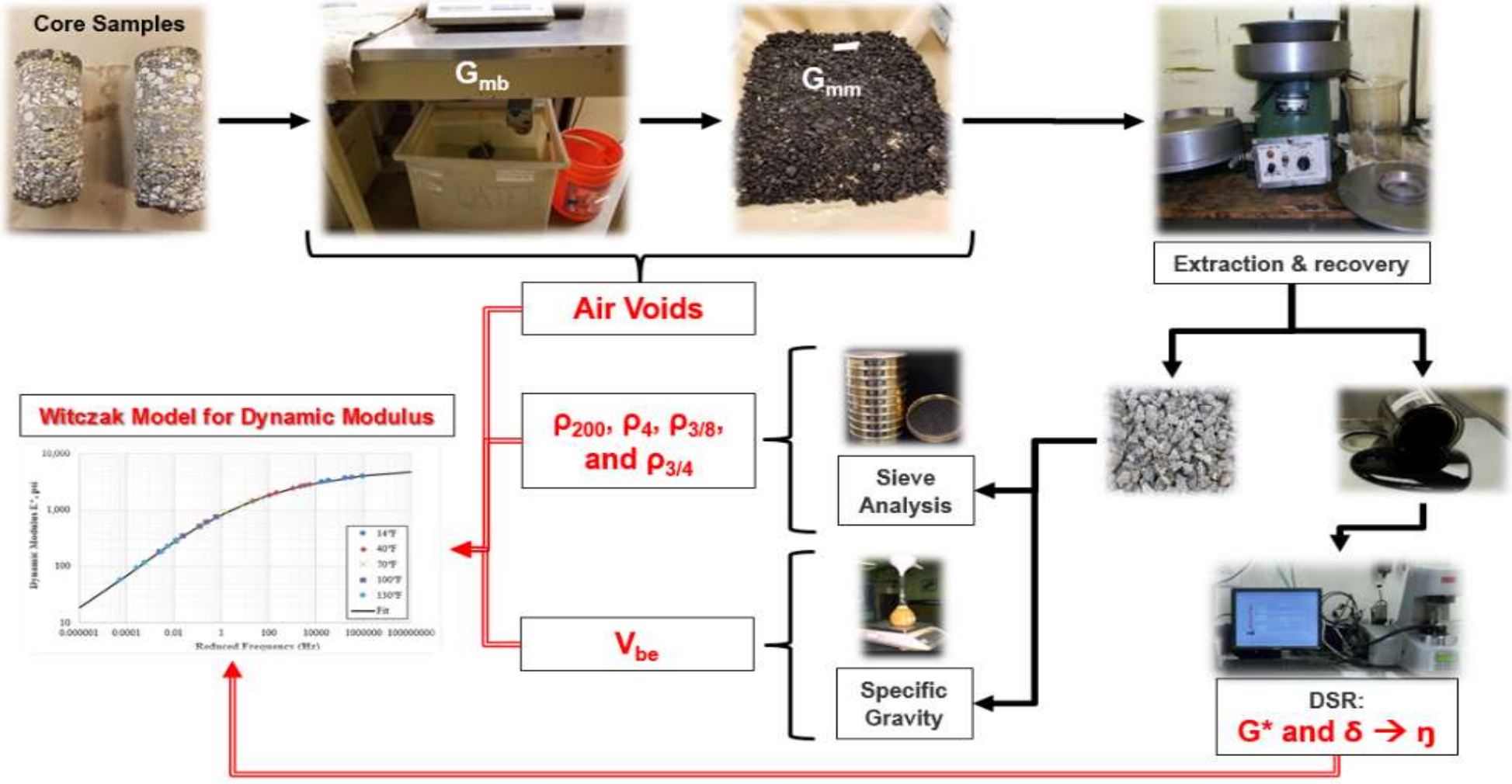
Undamaged Dynamic Modulus: *Witczak Model*



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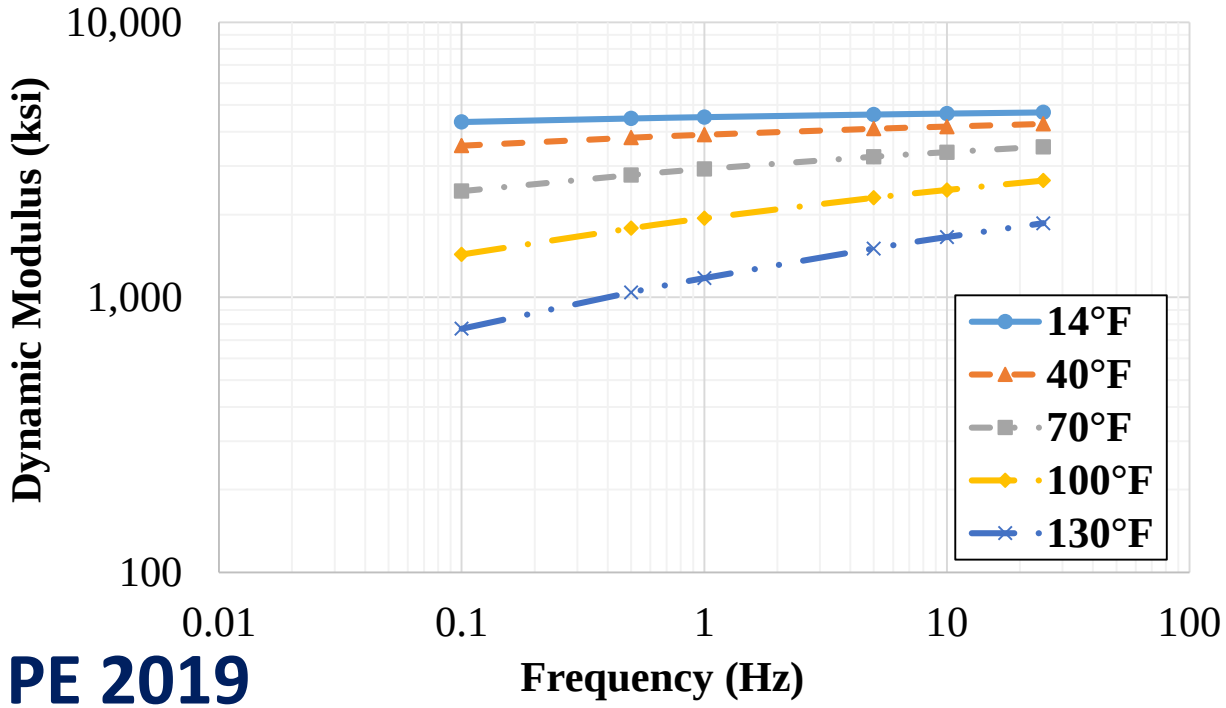
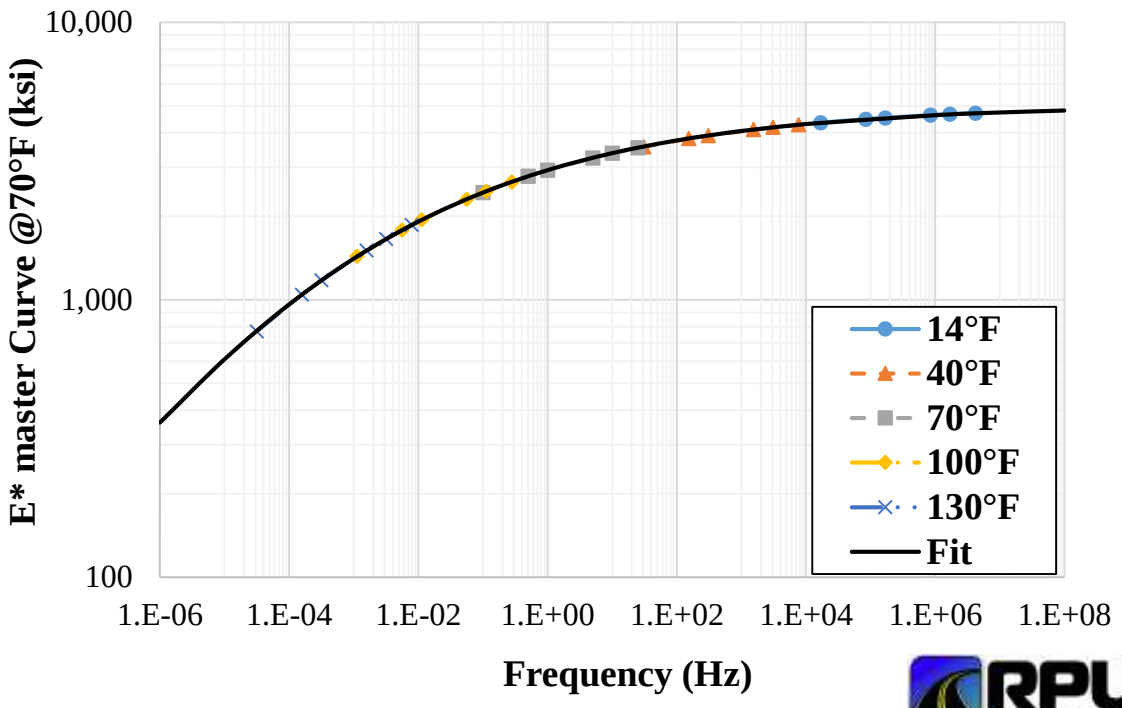
Undamaged Dynamic Modulus: *Witczak Model*

$$log|E^*| = 3.750063 + 0.02932\rho_{200} - 0.001767(\rho_{200})^2 - 0.002841\rho_4 - 0.058097V_a - 0.802208\left(\frac{V_{b_{eff}}}{V_{b_{eff}} + V_a}\right) + \frac{3.871977 - 0.0021\rho_4 + 0.003958\rho_{38} - 0.000017(\rho_{38})^2 + 0.005470\rho_{34}}{1 + e^{(-0.603313 - 0.313351\log(f) - 0.393532\log(\eta))}}$$





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Damaged Dynamic Modulus: *FWD Testing*

- Should existing AC layers be characterized separately?
- Can the AC layers be separated during the FWD analysis?
- How existing AC layers will be modeled in Pavement ME?

Modulus of existing AC layer obtained from FWD testing		
FWD Modulus (ksi)	**Frequency (Hz)**	**Temperature (°F)**
750	15	88

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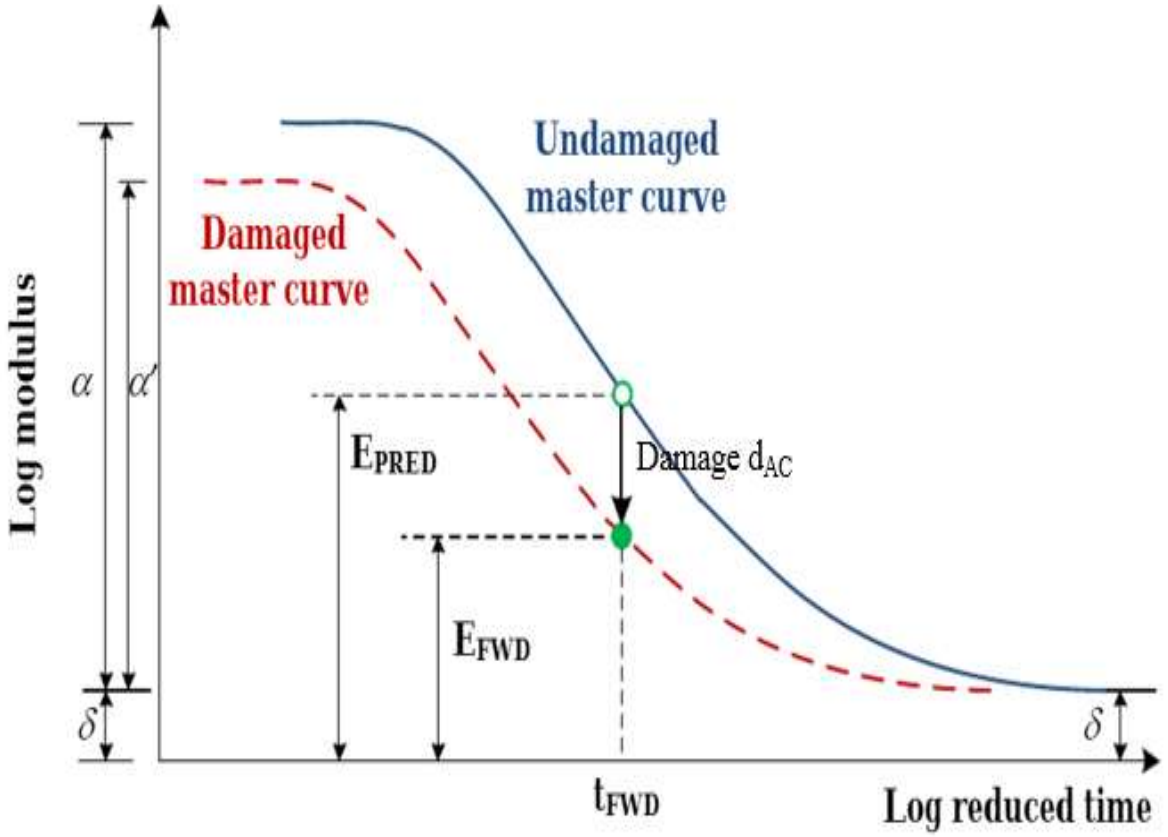
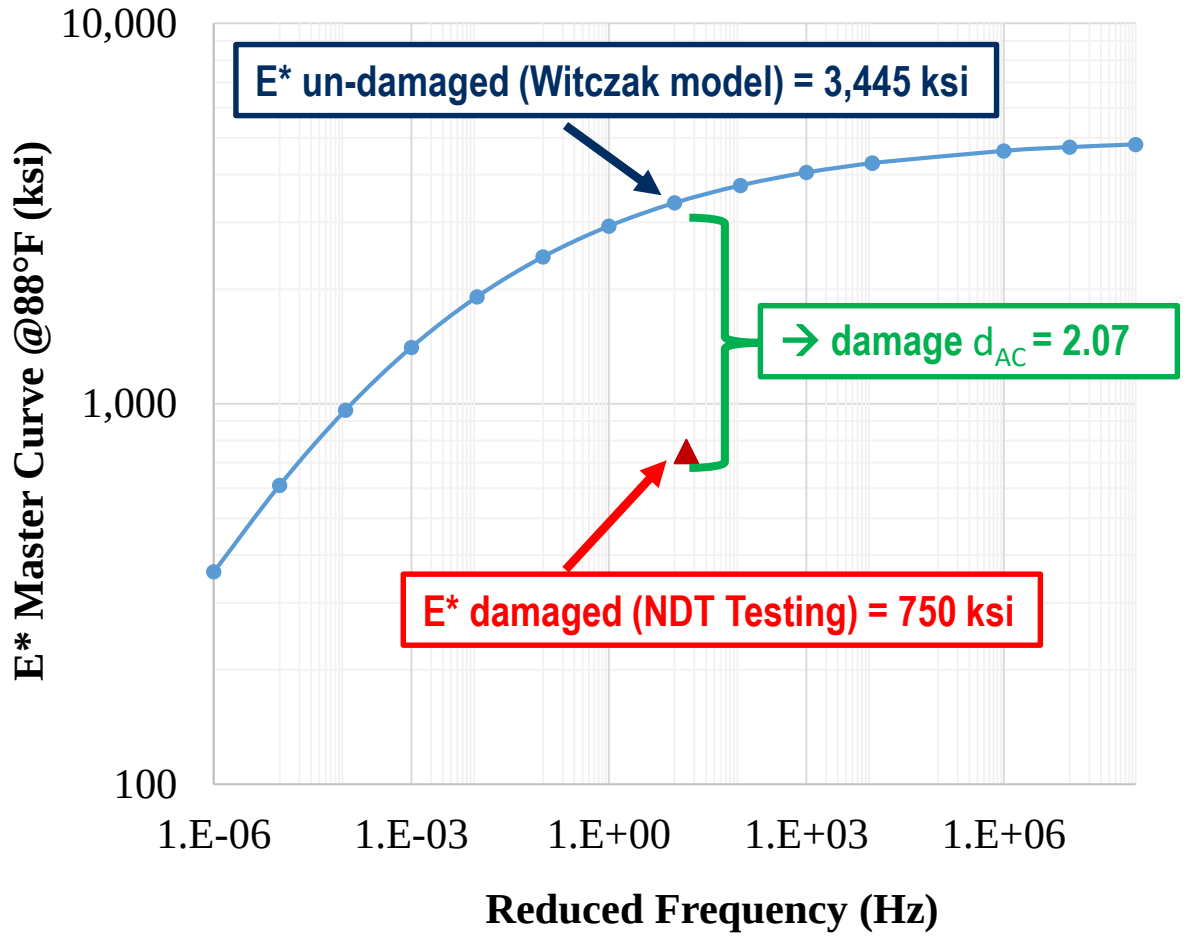
Damage Characterization Based on MEPDG Approach *(Estimation of FC Damage)*



$$E^*_{dam} = 10^{\delta} + \frac{E^* - 10^{\delta}}{1 + e^{-0.3+5\times\log(d_{AC})}}$$



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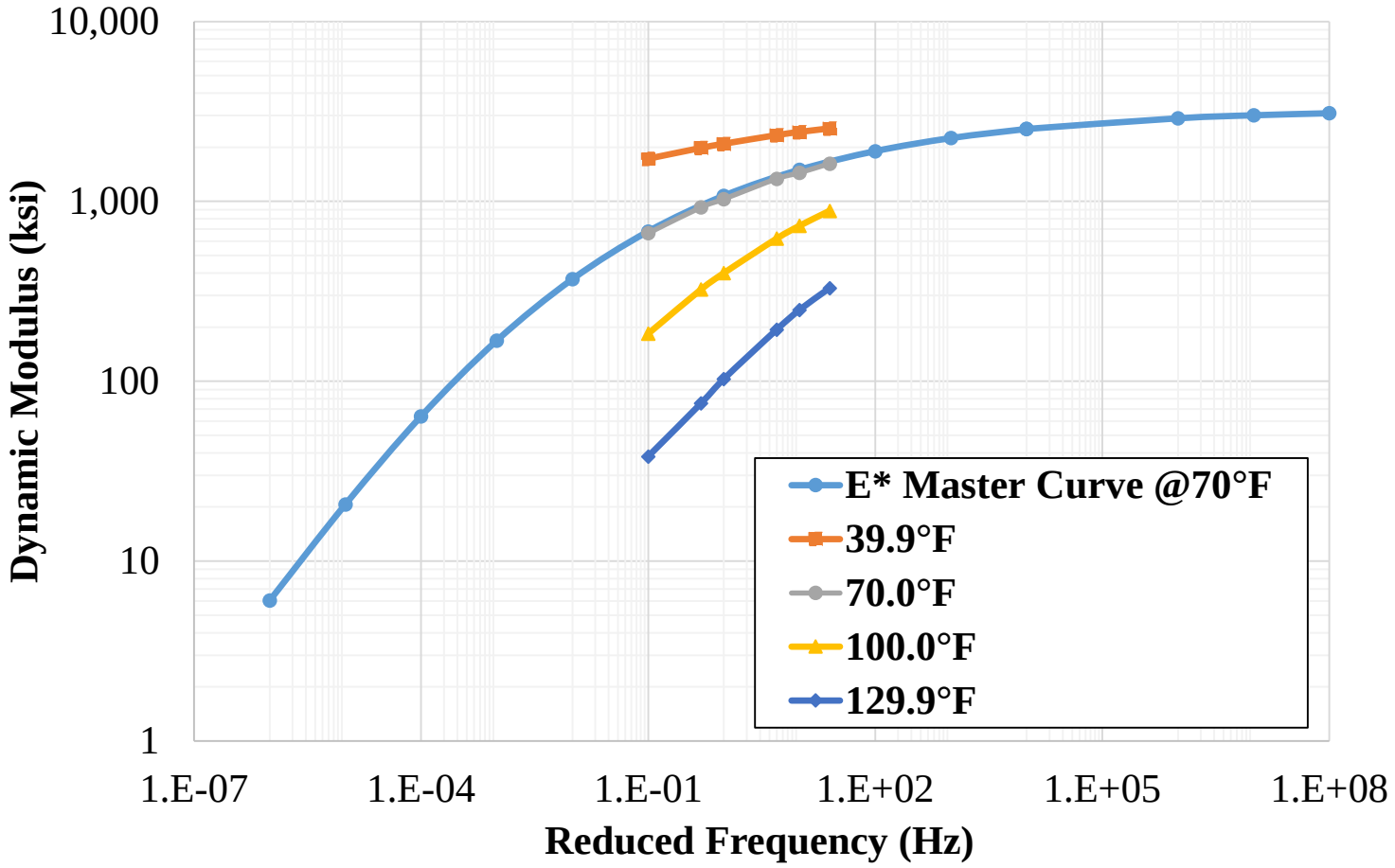
Undamaged Dynamic Modulus: *E* Testing of Cores*



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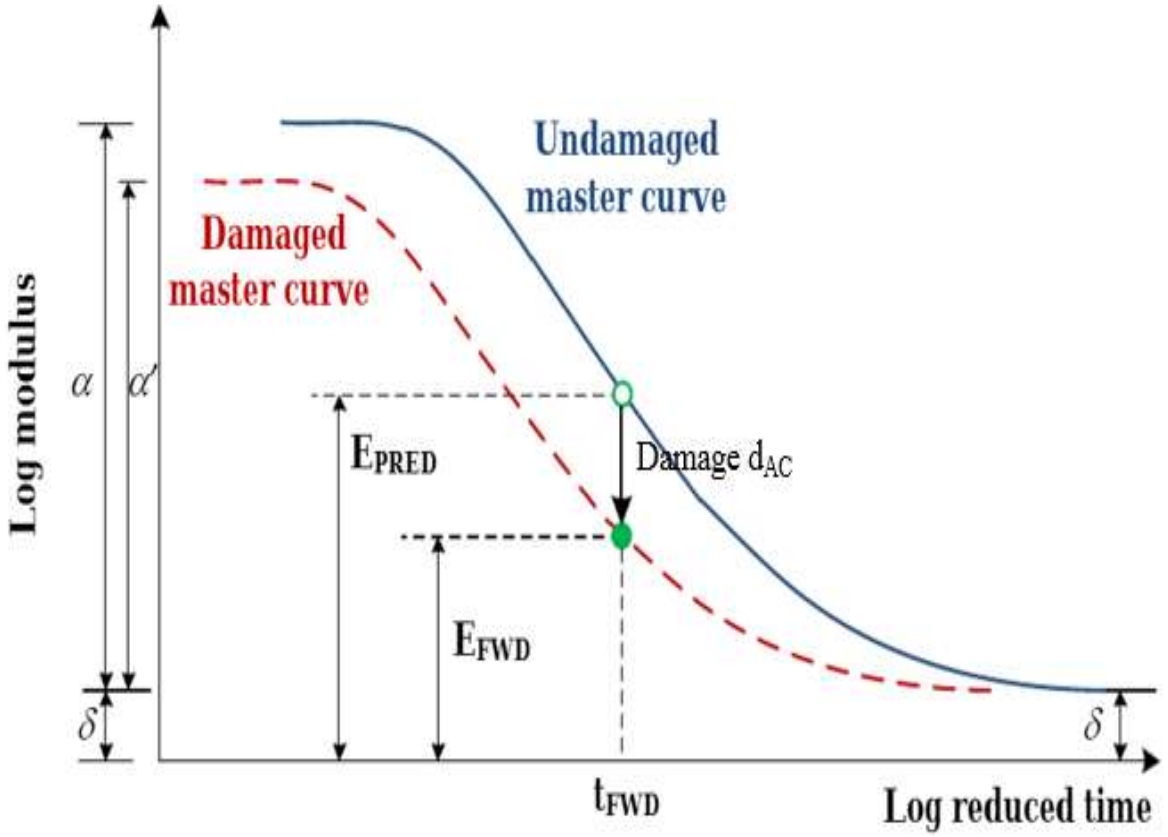
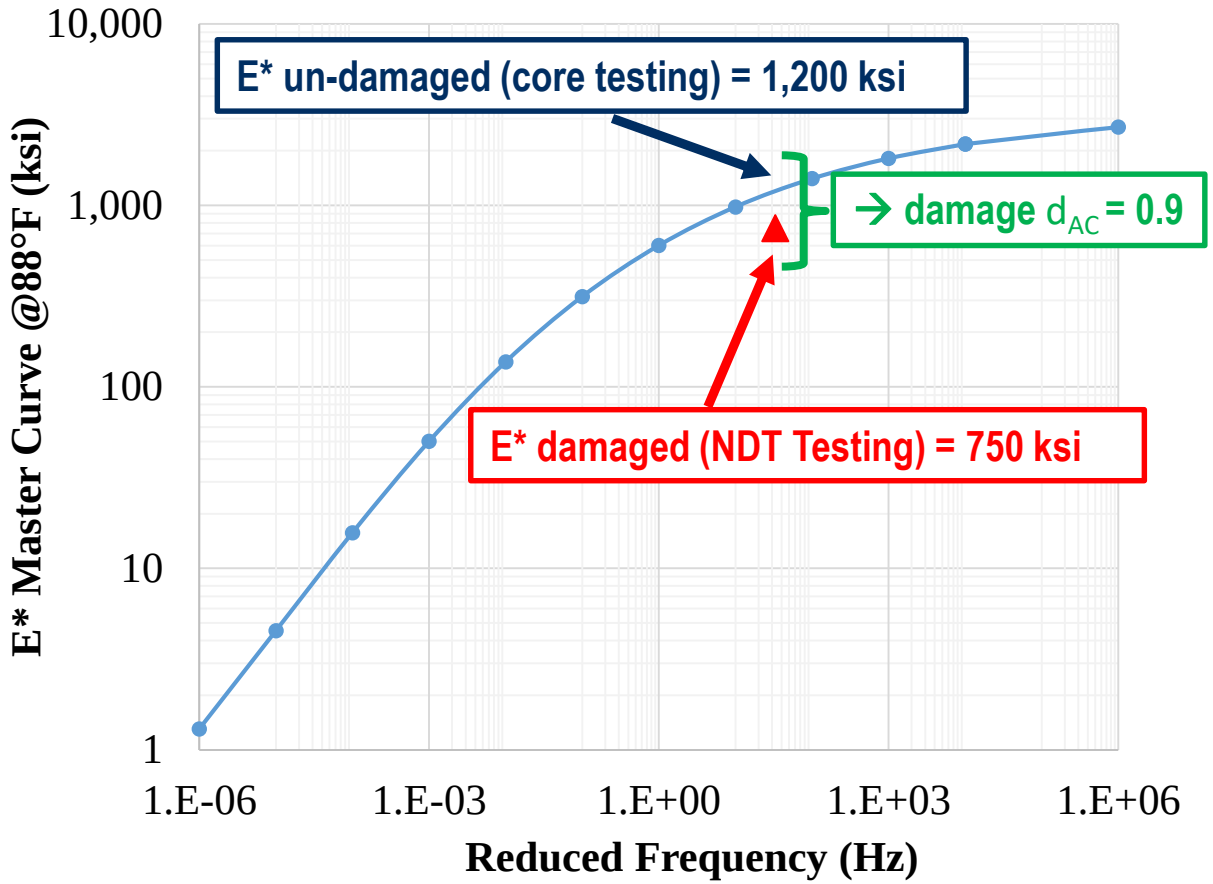
Damage Characterization Based on *HYBRID* Approach *(Estimation of FC Damage)*





$$E^*_{dam} = 10^{\delta} + \frac{E^* - 10^{\delta}}{1 + e^{-0.3+5\times\log(d_{AC})}}$$

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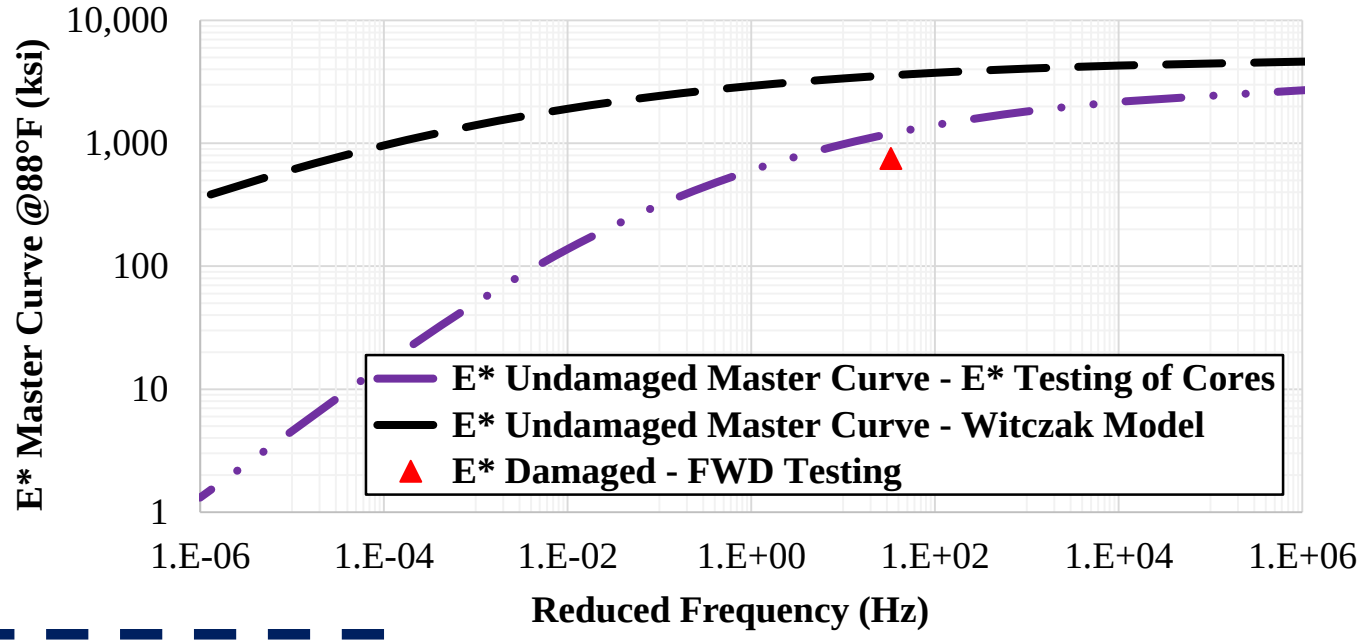
FC Damage Characterization: *MEPDG* vs. *Hybrid* Approach

- Estimated Damage d_{AC}:

❑ Using Witczak model $E^*_{(undamaged)}$ & FWD $E^*_{(damaged)}$: ***2.07***

❑ Using $E^*_{(undamaged)}$ of cores tested in the lab & FWD $E^*_{(damaged)}$: ***0.9***

Category	Damage d_{AC}
Excellent	0.00 – 0.20
Good	0.20 – 0.40
Fair	0.40 – 0.80
Poor	0.80 – 1.20
Very Poor	> 1.20



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→ PMS Data ????

Percent Alligator Cracking: *MEPDG* vs. *Hybrid* Approach

$$FC_{Bottom} = \left(\frac{1}{60}\right) * \left(\frac{C_4}{1 + e^{(C_1 * C_1^* + C_2 * C_2^* * \log(d_{AC-Bot} * 100))}}\right)$$

- FC_{Bottom} = Area of alligator cracking, % of total lane area;
- $d_{AC\text{-}Bot}$ = cumulative damage index at the bottom of AC layer;
- $C_1 = 0.8$; $C_2 = 0.8$; and $C_4 = 6000$
- $C^*_1 = -2 * C^*_2$
- $C^*_2 = -2.40874 - 39.748 * (1 + h_{AC})^{(-2.856)}$

Parameters / Approach	MEPDG	HYBRID	PMS Data (2014)
Damage d_{AC}	2.07	0.9	0.7
Area of Alligator Cracking	***65.2%***	***47.9%***	**42.2%**

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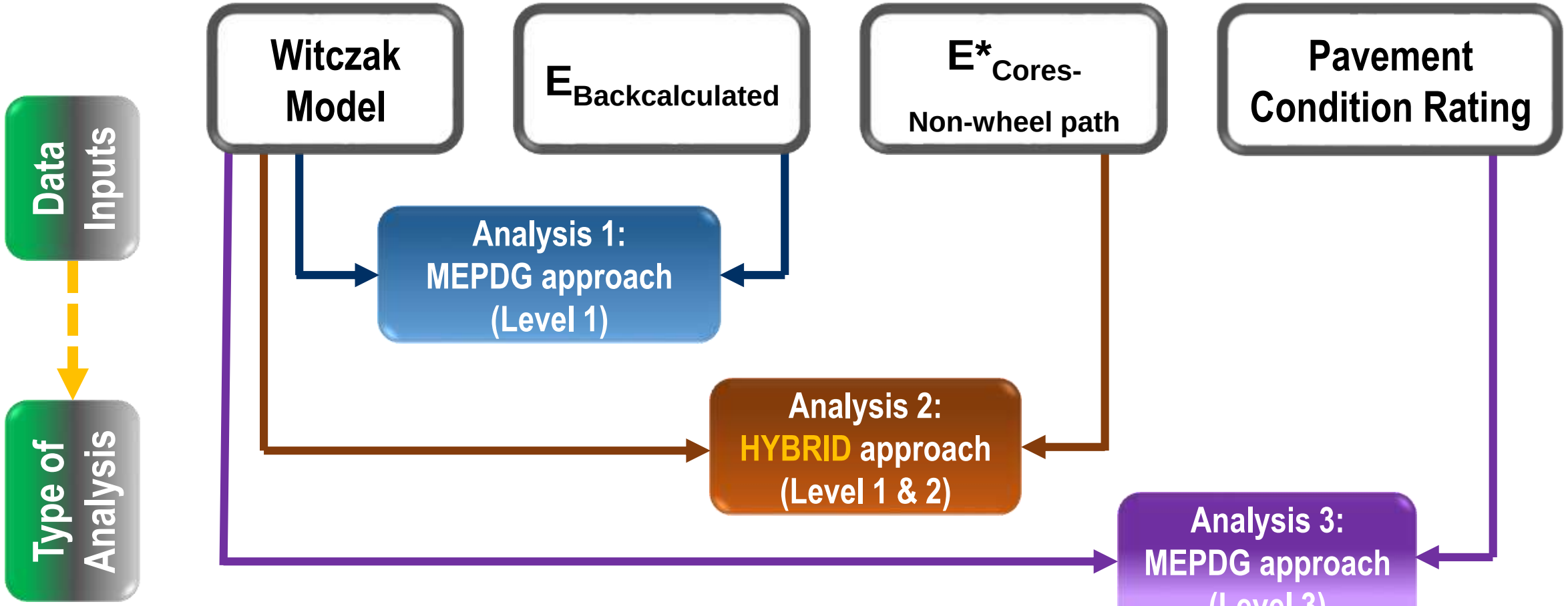
Pavement Rehabilitation Analysis



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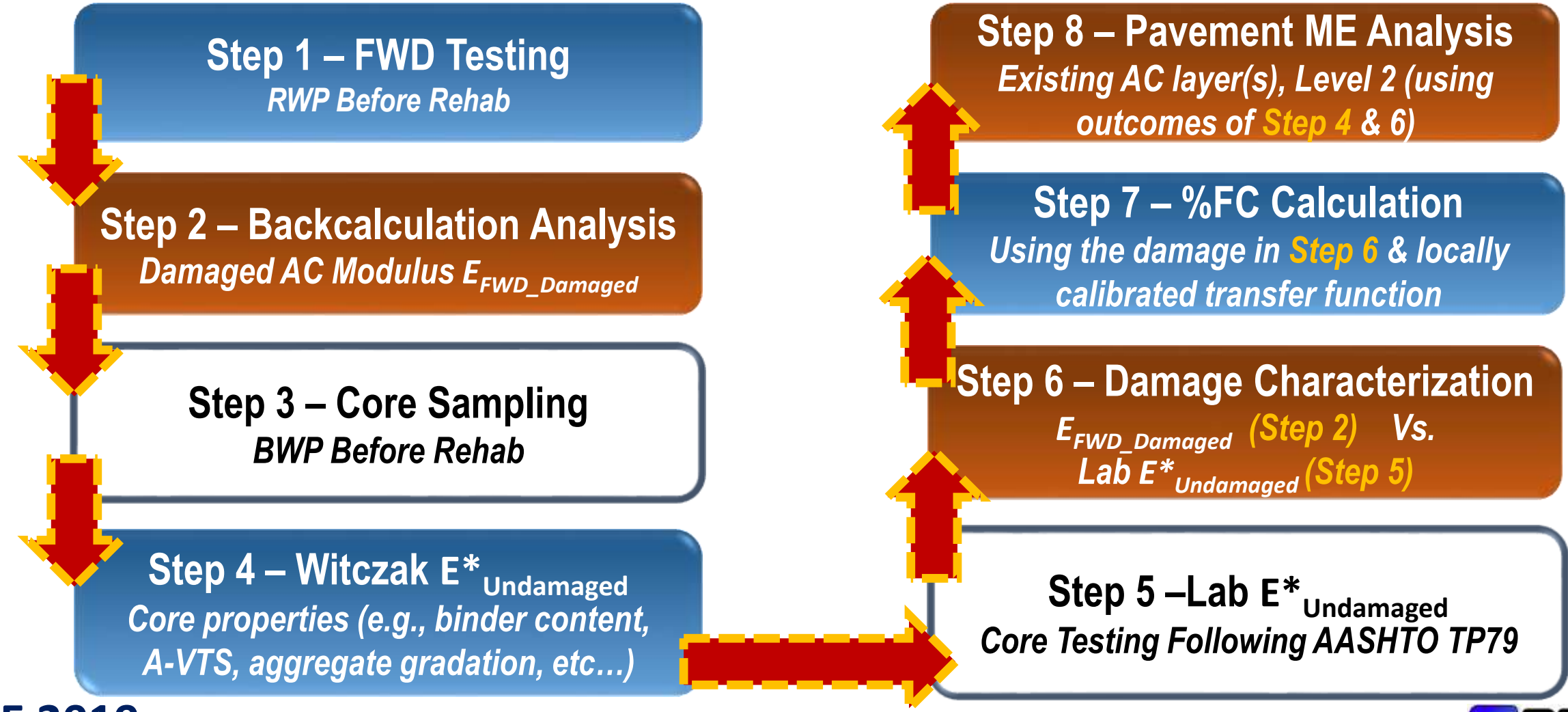
Findings & Conclusions

- *Higher damage characterization* was observed for the existing AC layer(s) when the Witczak model and FWD backcalculated data were used for undamaged and damaged E*, respectively.
- *Reasonable results for damage* were observed when estimated using the measured undamaged E* on cores combined with damaged E* from FWD backcalculation.
- The implementation of the *Hybrid* approach in the Pavement ME design software requires the use of a *combination of Level 1 and Level 2 data inputs*.

Recommendations: *Hybrid Approach*



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Acknowledgments

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Thank You! Questions?!

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