INFLUENCE OF PAVEMENT MATERIAL PROPERTIES ON TIRE / ROAD SURFACE NOISE

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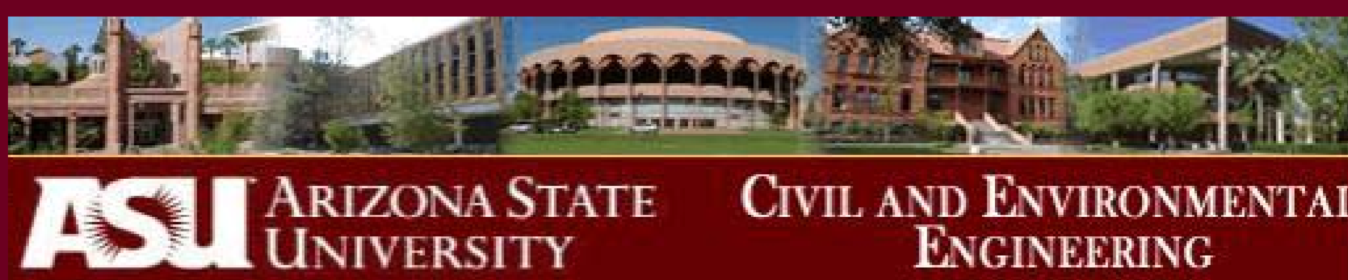
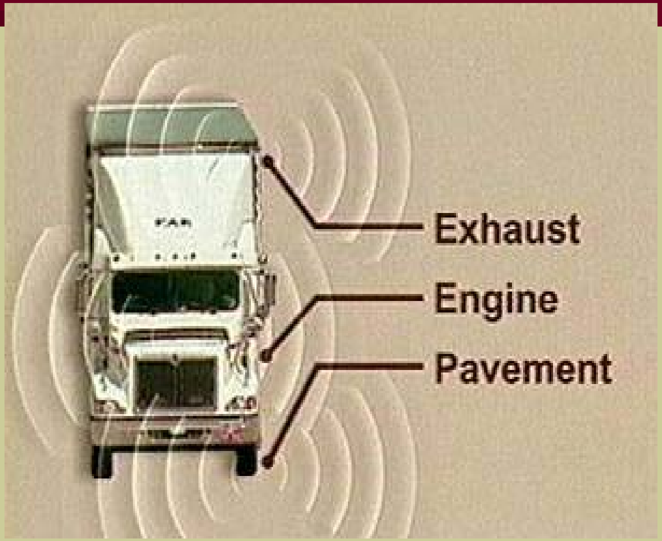


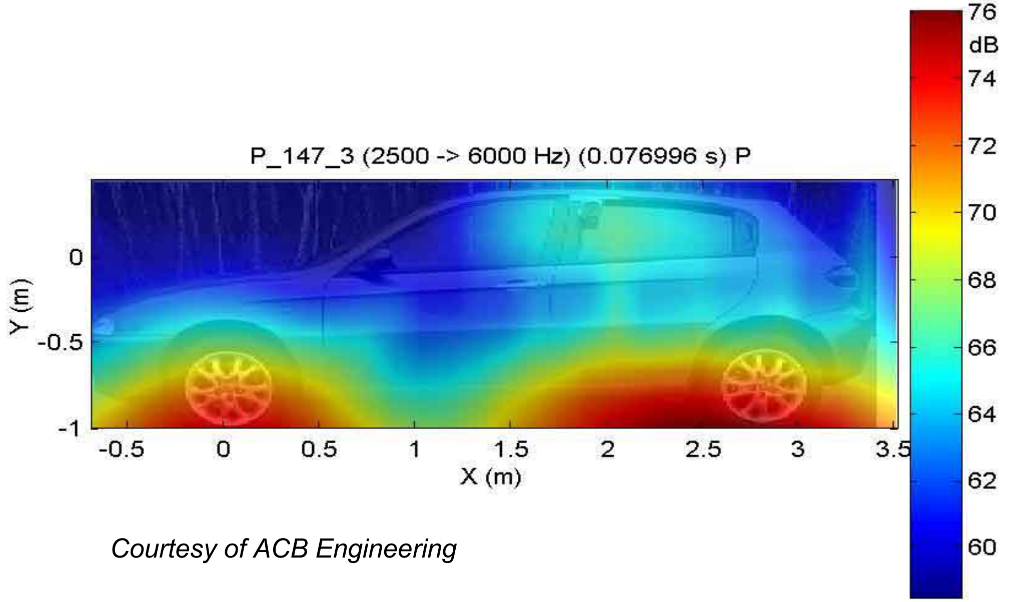
ROAD TRAFFIC NOISE

- A major problem in metropolitan areas.
- Automotive technology in the last 25 years >> noise decreased by 6 dB
- Traffic volume adds about 8 to 10 dB to the highway noise.



- High concrete sound barriers (walls) along city freeways mitigates highway noise, but they are very expensive.
- Usage of Open Graded / Porous Friction course pavements has mitigated highway noise successfully around the world.

NOISE EVALUATION STUDIES



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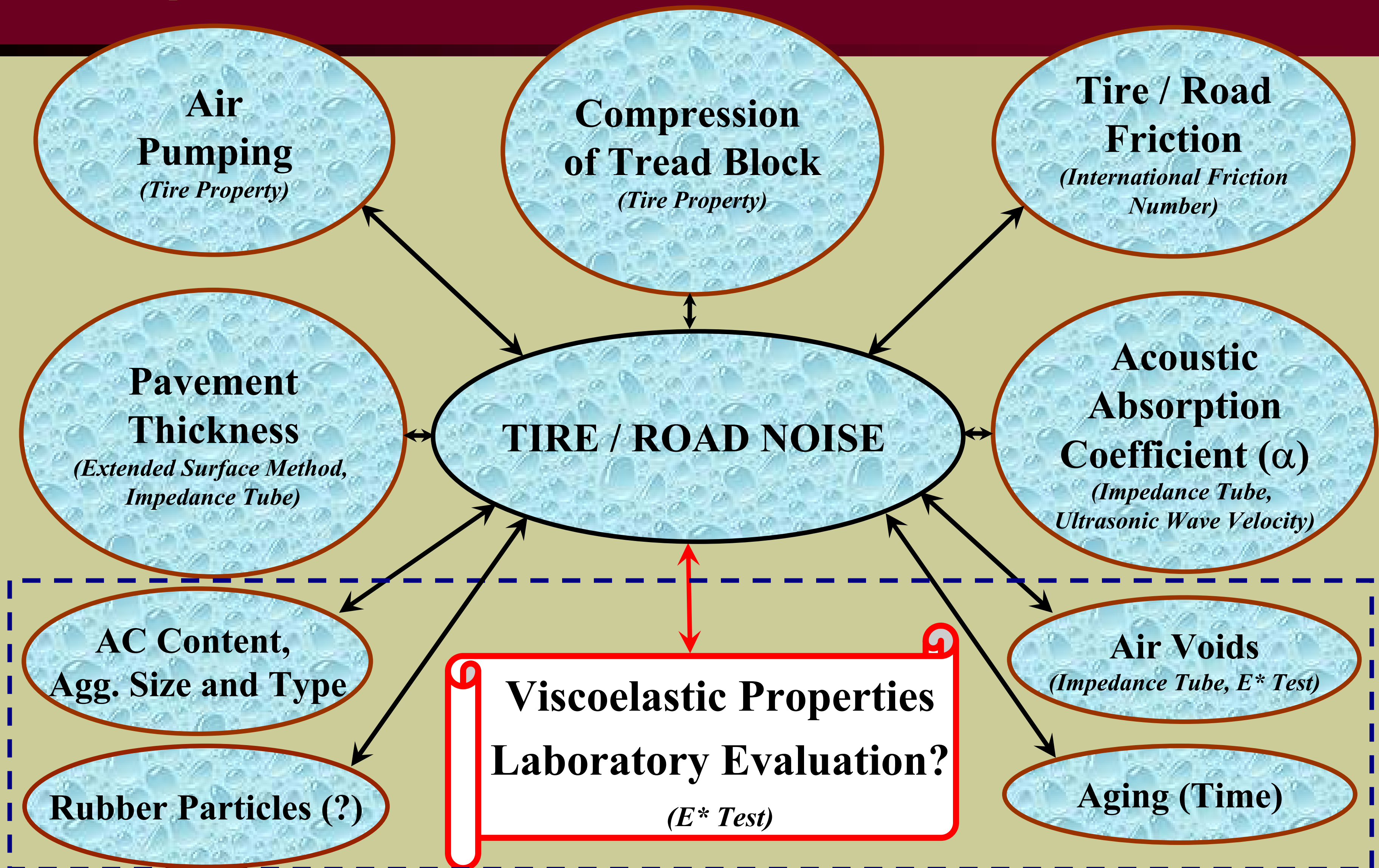
DOMINANT NOISE FACTORS ?

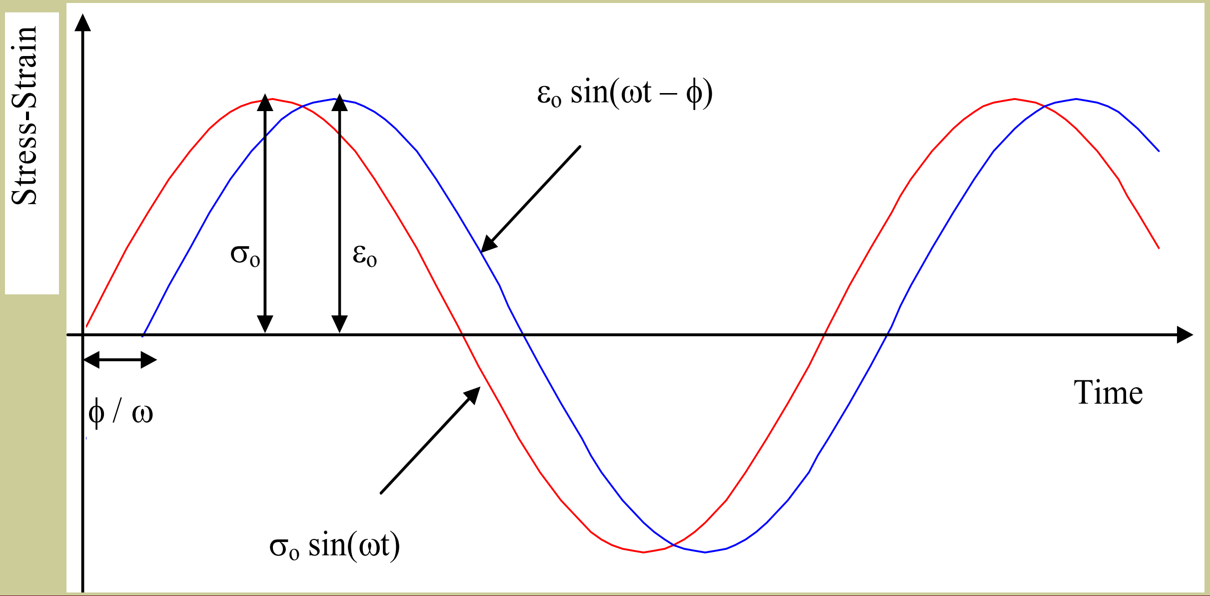


VISCOELASTIC PROPERTY = E* DYNAMIC MODULUS TEST

- Recommended Simple Performance Test under the NCHRP Project 9-19.
- Major Input Parameter for: Mechanistic Empirical Pavement Design Guide (MEPDG).
- ASU has largest database on E* tests on asphalt mixtures (including modified mixes).
- Can it be used as one of the parameters to assess Tire / Pavement Noise ?

DYNAMIC COMPLEX MODULUS (E*)

- **$|E^*|$ = Dynamic Complex Modulus = σ_o / ε_o**
- **σ_o = peak dynamic stress amplitude (kPa / psi)**
- **ε_o = peak recoverable strain (mm/mm or in/in)**
- Φ = phase lag or angle (degrees) = VISCOELASTIC PROPERTY



VISCOELASTIC PROPERTY = PHASE ANGLE, ϕ

$$\tan \phi = E'' / E'$$

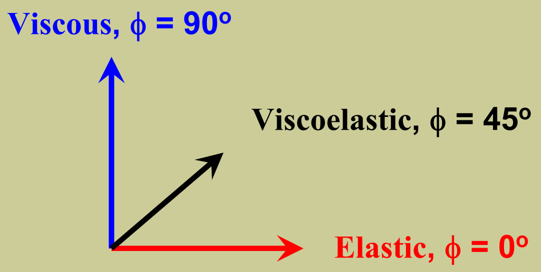
- $E^* = E' + iE''$,
  - E' = Storage (Elastic) Modulus = $(\sigma_o / \varepsilon_o) \cos \phi$
  - E'' = Loss (Viscous) Modulus = $(\sigma_o / \varepsilon_o) \sin \phi$
- Mathematically,

$$\phi = (t_i / t_p) \times (360)$$

t_i = time lag between a cycle of stress and strain (sec)

t_p = time for a stress cycle (sec)

- Expressed in Degrees
- For a pure elastic material, $\phi = 0°$
- For a pure viscous material, $\phi = 90°$



OBJECTIVE

- **To analyze E* test results (*specifically Phase Angle ϕ*) for asphalt mixtures to assess the tire / pavement surface noise characteristics.**

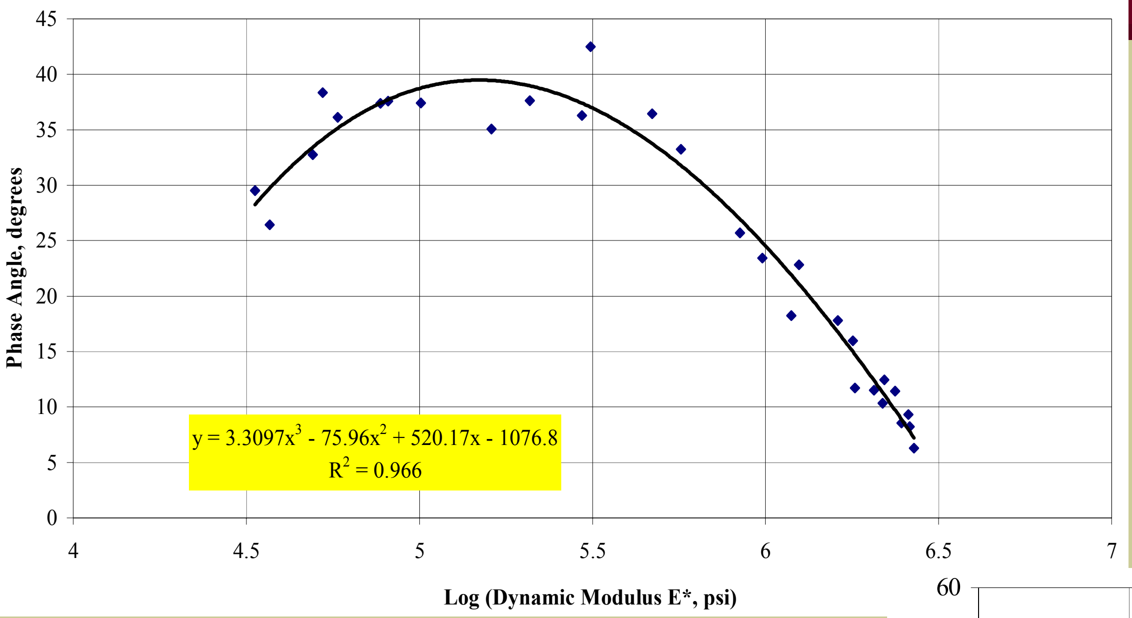
- ***Hypothesis: more viscous behavior would provide more noise dampening effect, leading to less tire / pavement surface noise.***

MIXTURES

Mix	Conventional Dense Graded	A-R Open Graded (AR-ACFC)	A-R Gap Graded (ARAC)
Total No. of Mixes	148	26	34
Air Voids (%)	4-8	~18	8-11

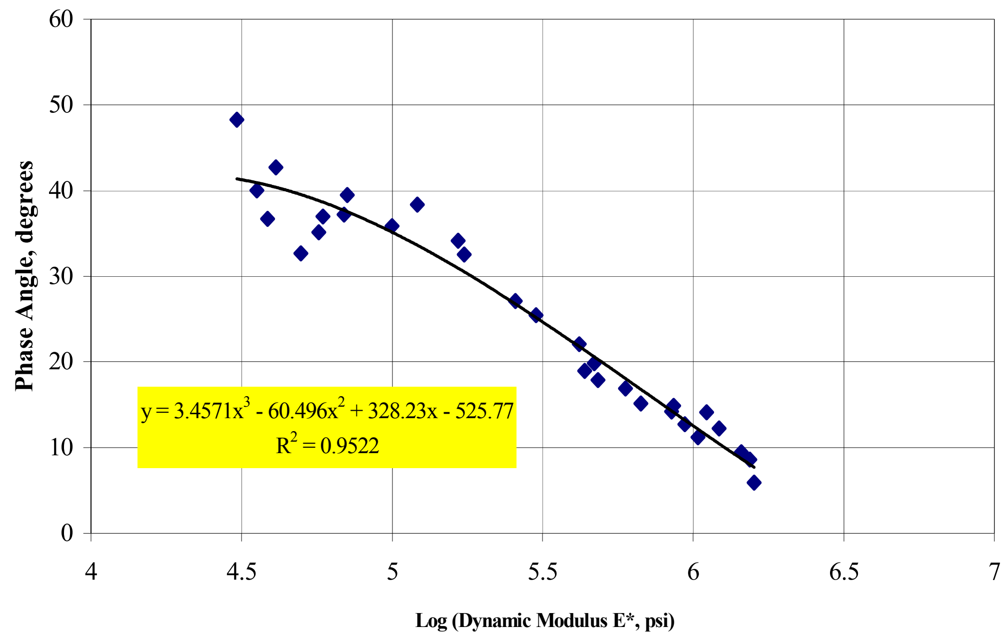
- Φ = Viscoelastic Property
- Storage and Loss Moduli

PHASE ANGLE RELATIONSHIPS
Conventional vs. Asphalt Rubber



Conventional Dense Graded Mix

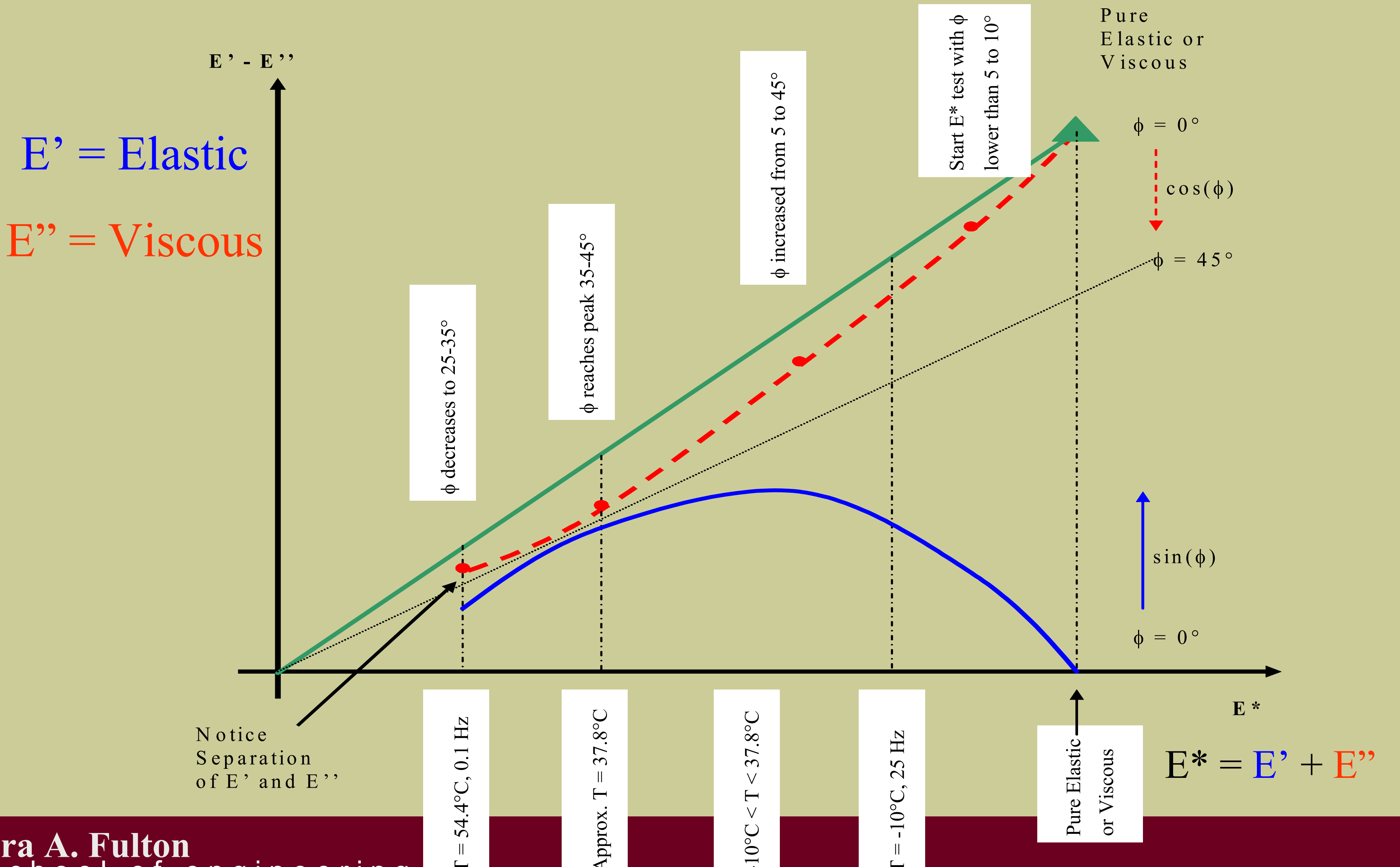
Asphalt Rubber Mix



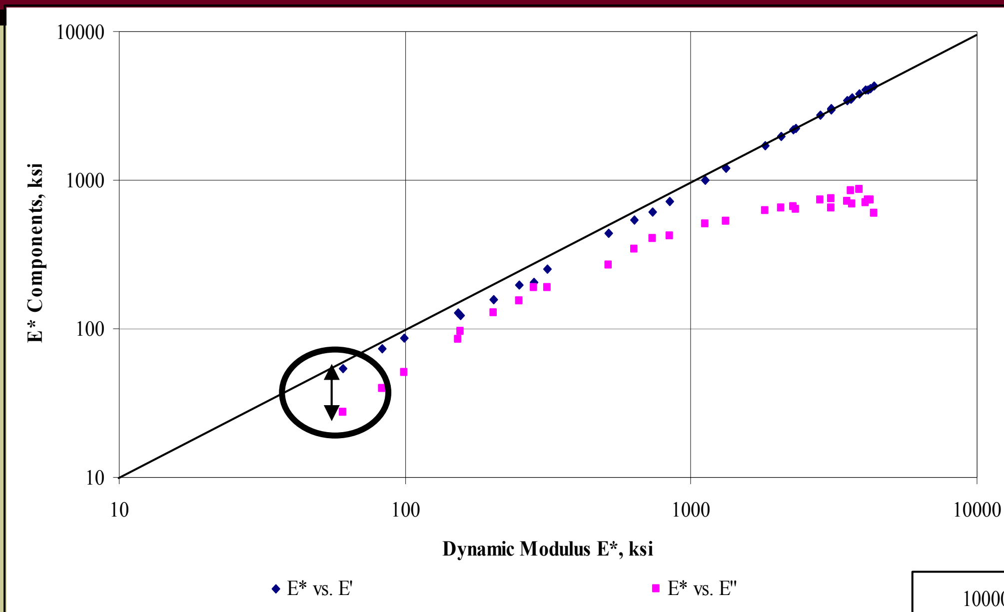
E* / ϕ TEST DATA & RESULTS

Mix	Conventional Dense Graded	A-R Open Graded (AR-ACFC)	A-R Gap Graded (ARAC)
Total No. of Mixes	148	26	34
Air Voids (%)	4-8	~18	8-11
Avg. Peak ϕ (degrees)	29	42	37

E* VERSUS E' - E'' SCHEMATIC RELATIONSHIP



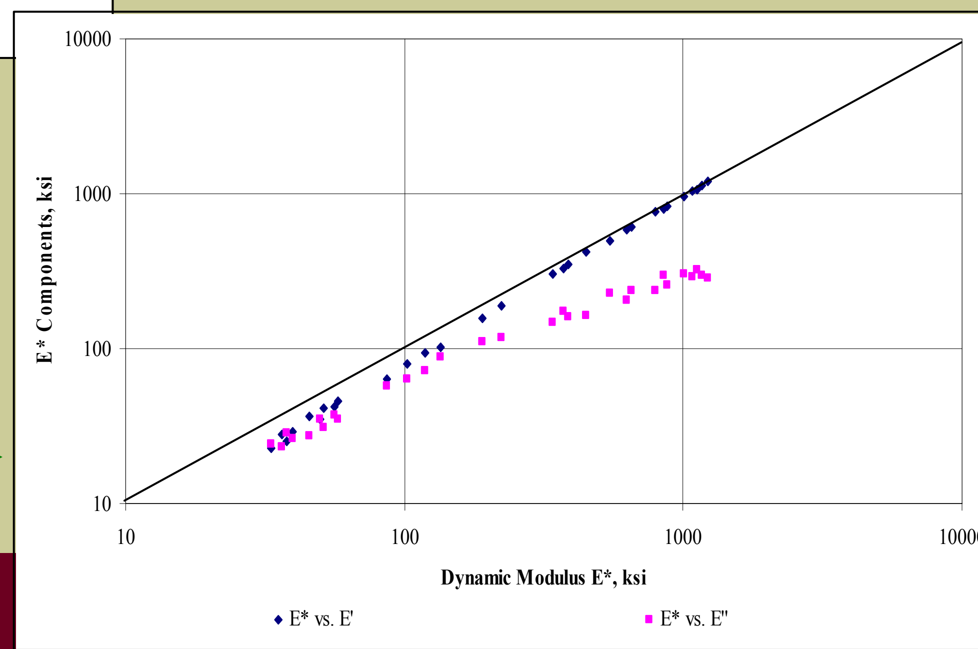
TYPICAL E* VS. E'-E'' RELATIONSHIPS



- E' = E'' means less noisy pavement.
- Conventional mix: elastic at low E* values (high temperatures and low frequencies).
- AR mixes: E' = E'' at high temperatures => modulus viscoelastic properties of the mix.

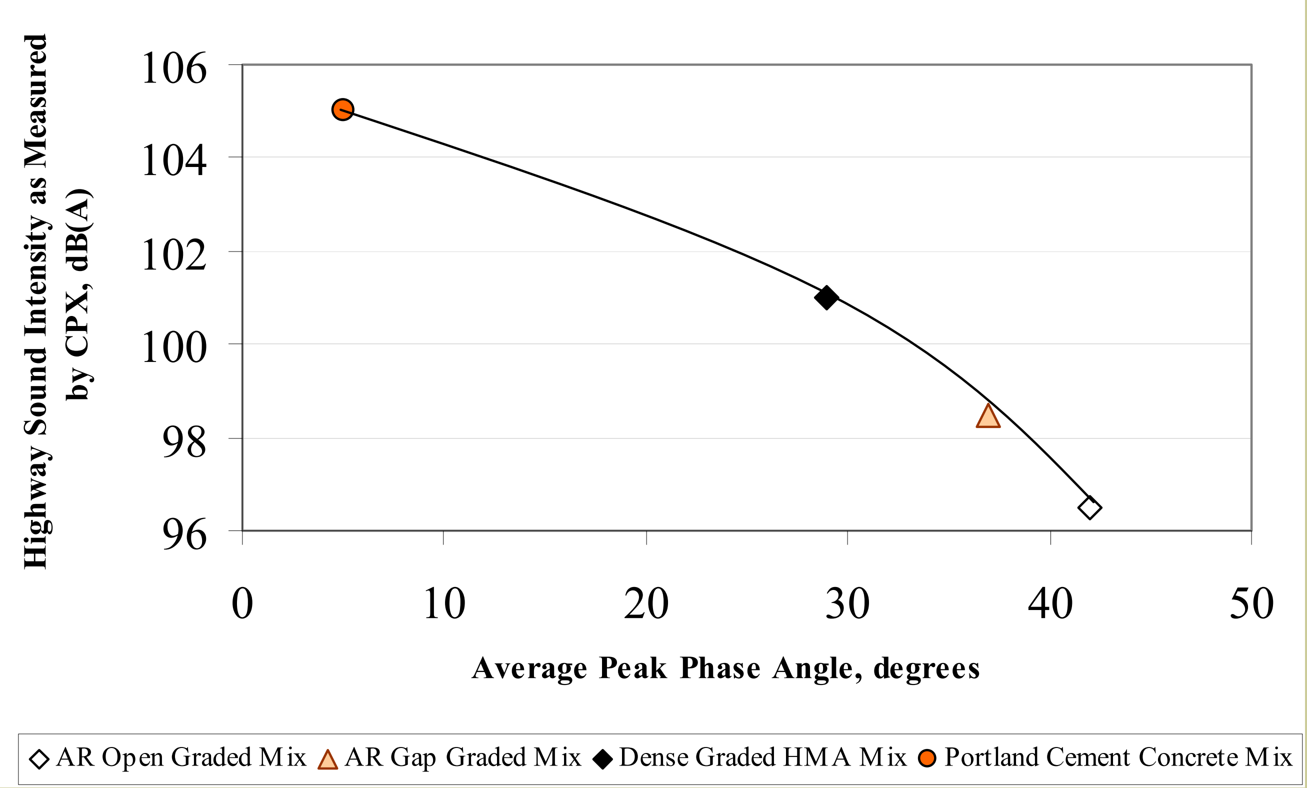
Conventional Dense Graded Mix

Asphalt Rubber Mix



PHASE ANGLE VS. CPX Sound Intensity

Surface Type	Sound Intensity [dB(A)] CPX Method
AR-ACFC	96-97
ARAC	98-99
HMA Conventional	100-102
Portland Cement Concrete	101-109



CONCLUSIONS

- **Phase angle potentially a tire / pavement surface noise discriminating parameter between asphalt concrete mixtures.**
- **Good correlation between the average ϕ of each mix type and the sound intensity measured for each surface type >> Viscoelastic Property.**
- **Viscoelastic properties of the mix from the laboratory E* test *contribute* to the explanation of the tire/pavement surface noise reduction observed in the field.**

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Questions & Comments