

# SUMMARY/COALESCENCE OF MODELS

- (1) Contribution of each model to a unified predictor of pavement performance
- (2) Missing elements among models

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- Compositional Models Session.
  - Comments from session moderator John D'Angelo. Sees beginning of molecular, chemical, etc. models for AC is mathematics and computing comparable to NIST. Troy Pauli's work on microstructure needs to build from other work, clear understanding of links between surface energy, components (asphaltenes, etc.) and performance needed. How do we characterize aging? Start with Claine Petersens's work with the 'spurt' and then gradual increase in aging. It was very interesting to see aging rates vs. depth vs. volumetrics. Need to revisit the Mechanistic Empirical Pavement Design Guide with work at the Pavement Performance Prediction Symposium. Tying all of these together (microstructure-aging-etc) is direction needed to go.
  - (Copeland/Arnold) If new material/binder comes along, is there a coherent plan as to how to understand a new material? (D'Angelo) start with understanding how new materials interact with existing materials/polymers, i.e. Sulphur asphalt did not have polymer in past but any future reintroduction would have polymer.
  - (Glover) continue developing computation models for oxidation and then effects on binder properties then link back to the pavement,
  - (Pauli) Work must be based on fundamental science, thermodynamics, mechanics, etc. This is the philosophy of WRI, complexity of PMA is challenging but other industries follow fundamentals – continue,
  - (Bonaquist) One gap with respect to compositional models, most work is down without presence of aggregate, must look at interaction between asphalt and aggregate especially polymer and mineral filler
  - (Wasiuddin) aggregate properties is a gap, i.e. absorption, surface characteristic (energies, areas), mix design parameters, regarding WMA + additives and AASHTO guidelines for viscosity could benefit from more attention also including loose mix viscosity (workability).
  - (Greenfield) Regarding compositional models; different composition leads to different performance, we should develop simple characterization methods.
- Rheological Models Session
  - Comments from session moderator Gaylon Baumgardner – good presentation from Bahia on binder and interaction with additives, differences in opinion on

ability of models discussed. The current PG spec is intended for purchase but Bahia poses should in some way include other mixture parameters. Thus, could different methods of design be incorporated with Bahia's effect of mix design and fundamentals. With Little's work, seems getting closer to incorporating models and fundamental properties, the missing element is the effects of additives (WMA, antistrips) on surface energy, not just Wilhemly plate but mixtures as well. Regarding Marastenu's work, was encouraged by work on BBR like DMA (TTI), MSCR; where small samples of mixture can be characterized, not just binder. Marrying these together can bring us closer to predictive model. Also, how do we age mixtures and correlate to mixture aging. Incorporate physical hardening into models.

- (Petersen) Regarding fundamental research and polymers, we must work to understand the absorption of asphalt components into the polymer, understand the implications of solubility of different components, i.e. polar aromatics were absorbed in the presence of SBS and could very well change the aging characteristics, understand the remaining components of the asphalt.
- Mixture Models Session
  - Comments from session moderator Jack Youtcheff – Model from Scarpas/Kringos is very robust, inclusion of interface effects and chemical interaction with water, Garbozi showed how to utilize tools from other material as how to reduce the number of tests we are doing, Roque's fracture mechanics included continuum damage and the fracture propagation – where does it become irreversible? – tie in Acoustic Emission tools. Lytton's summary of micromechanics also brought up behavior at the interface and how to relate to bulk phase behavior, how does that affect fracture initiation and propagation. We should be looking at common materials when it comes to fracture work, include more environmental conditioning, also we should be looking at thermal cycling and any effects on dewetting-wetting. Incorporate these issues into experimental design. Work on microbes should identify presence and mechanism of damage or benefit.
  - (D'Angelo) major gaps such as with packing of aggregates at smaller scales and interaction with binder, effects of surface textures. Taking these into consideration how does this and structure influence fracture. We should be doing similar things as NIST's VCCTL.
  - (Robertson) comment on Roque's work on accumulation of damage / healing. Urge to keep in mind concepts of threshold in accumulated damage. Re: microbes, pipeline industry has seen noticeable damage, they are omni-present. Removal of linear hydrocarbons (which soften AC) in crude processing creates ideal food source for microbes. Not saying microbes are a major cause but it is an understudied area. Of the few laboratory and field studies completed – they all show consistency. Are microbes altering the material properties of the material (asphalt aggregate interface).
  - (Youtcheff speaking for Roque) we must have a shared nomenclature

- (Scarpas) Thank you to all of WRI. Answering needs in 3 groups and prioritizing. What is missing for modeling? Focus more on the influence and simulation of interface. How to obtain parameters for interface simulation? Those involved in mechanics have not agreed on definition and nomenclature of cracking and fracture. A document should be prepared for circulation discussing terminology. 3D response could be investigated further. In the medium range, understanding moving loads and the implications of what is lost with current methods. Upscaling from micromechanics, infeasibility of millions of loads. Start from small scale, export properties to larger scales. Long term – Chemomechanics is more than likely the next major advancement in how molecules interact and mechanical effects on mixes. Suggest ISAP start chemomechanics committee. ISAP meets every year the Sunday before TRB. Regarding D’Angelo’s comment on aggregate response, Delft is doing work in this area, such as including anisotropy using tensor mathematics.
  
- Mechanistic Empirical Pavement Design Guide Models
  - Comments from session moderator Tom Harman – Schwartz’s presentation really captured our current state. There are many, many opportunities for enhancement. This community has strong influence and FHWA is supportive. Also, must be forward thinking when we set up experiments and programs like LTPP. There is an increased need for bulk materials storage and sharing. Al-Basyouny’s presentation an excellent update. Mike’s presentation presented comparison between current models and observations. Katherine’s presentation highlighted balancing risk and the need for more powerful models.
  - (Schwartz) Gaps – very sophisticated presentations here but then very crude simulation for what is going on in the pavement. We could rely less on advanced molecular effects with robust mechanistic models. Start by understanding well controlled products like the ALF. The gap is highlighted.
  - (Baumgardner) from the industry perspective, a lot of different crude sources must be analyzed. Looking at models to understand what processes are optimal. Suggest that coking may not be ideal, and the asphalt components should be saved. Contractors may not fully understand concepts of surface energy, absorption then extending to performance. We must move toward that because more and more crude sources are coming online.
  - (Glover) the MEPDG is a wonderful effort, we should not criticize. We need better understanding of oxidation in pavements, rates and impact on properties, which then influence pavement properties i.e. MS1 should have explicit shift with binder aging. Would like to see MEPDG computational structure simplified and more transparent, i.e. seeing the effect of aging, it cannot be turned off. It would be helpful to decouple as many phenomena as possible.