Introduction

Asphalt Binder Properties

**Consistency**
Asphalt is a *thermoplastic* material that softens as it is heated and hardens when cooled.

**Why Heat Asphalt? So It Can Be:**
- Pumped and transported
- Blended with and coat aggregate
- Remain workable during
  - Transport, laydown, and compaction

*Other Ways to Make Asphalt Workable:*
- Add solvents – cutback asphalt
  
  **Emulsify with water**
**Asphalt Emulsions – A History**

- First developed in the early 1900s
- Early use in spray applications + dust palliatives
- Growth use relatively slow:
  - Limited by the type of available emulsions
  - General lack of knowledge
- Steady rise in volume since the 1970’s

**Why Use Asphalt Emulsions?**

- No petroleum solvent required to liquefy
- Little or no hydrocarbon emissions
- In most cases, used with no additional heat
- The ability to coat damp aggregate
- Can use cold materials at remote sites
- Wide variety of emulsion types available today

**Preventive maintenance apps – Improved LCC!**

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**Asphalt Emulsions in Pavement Preservation (PP)**

- Strategy of managing pavement condition to:
  - Maximize pavement lifespan at minimal cost
- Applies to all types of roads
  - Low volume local roads to heavy interstates
- Achieved by careful planning and selection
  - Right protective treatment (application)
  - At the optimal (right) time

**Pavement Life Cycle Theory**

- Maintenance ~$ 1.00/SY
- Rehabilitation >$10.00/SY
- Reconstruction >$$$$

[Graph showing maintenance, rehabilitation, and reconstruction costs over time]
Emulsion Chemistry

- Emulsions are mixtures of
  - Two or more materials
  - Normally do not mix or blend together
  - Created via mechanical + chemical processes

- Some common examples
  - Mayonnaise, latex paint, ice cream

Asphalt Emulsions - Composition

- Three basic ingredients
  - Asphalt
  - Water
  - Emulsifying agent

- May contain other additives
  - Polymers
  - Stabilizers
  - Coating improvers
  - Antistrips
  - Break control agents

Basic Emulsion Ingredients – Asphalt

- Asphalt cement is basic ingredient
  - Up to 50-75% of finished emulsion
- Hardness of base asphalt cement varies
  - Emulsion base ranges from 40–250 dmm PEN
  - No exact correlation bwn. asphalt props. and emulsification
  - Climate may require harder or softer base
  - Compatibility of emulsifier needed for stability
**Basic Emulsion Ingredients – Water**

- Second basic ingredient in an emulsion is water
  - Contribution cannot be minimized
- Water may contain minerals or other matter
  - Can affect the production of stable emulsions
- Water considered suitable for drinking,
  - Might NOT be suitable for emulsion production

**Basic Emulsion Ingredients – Emulsifying Agents**

- Surfactants
  - Adsorbed at interface between liquids and solid
  - Concentrate at interface based on their structure
    - Hydrophilic head towards more polar phase (H₂O)
    - Lipophilic tail towards less polar phase (asphalt)
  - Surfactant molecule or ion acts as bridge bwn. phases

**Asphalt Emulsions – Emulsifying Agents**

- Asphalt emulsions are classified into three categories
  - Anionic (-)
  - Cationic (+)
  - Nonionic (neutral)

Based on electrical charges surrounding asphalt particles
Emulsion Production

Producing the Emulsion - Emulsifying Equipment
- Basic equipment
  - High-speed, high-shear mechanical device
  - Usually colloid mill to shear asphalt into droplets
- Also required
  - Emulsifier solution tank
  - Hated asphalt tank
  - Pumps
  - Flow-metering gauges

Producing the Emulsion – Emulsification Process
- Asphalt particle size vital factor for stable emulsion
  - Smaller than:
    - 0.001 millimeter (1 micron) 20 percent
    - 0.001–0.005 millimeter (1–5 microns) 57 percent
    - 0.005–0.010 millimeter (5–10 microns) 23 percent
Emulsion Classification

Asphalt Emulsions – Classification by Set Rate

• How quickly do asphalt droplets coalesce?

• Two letter codes used to simplify + standardize
  • RS – Rapid Setting
  • MS – Medium Setting
  • SS – Slow Setting
  • QS – Quick Setting

• Relative terms only

Proportional to break speed after contact agg. surface

Asphalt Emulsions - Classification by Set Rate

• RS Emulsions
  • Little/no ability to mix with aggregate

• MS Emulsions
  • Can mix with coarse but not fine aggregate

• SS and QS Emulsions
  • Can mix with fine aggregate
  • QS expected to break more quickly than SS

Sub-Classifications - Typical Applications

• RS
  ▪ Rapid Setting
    ▪ Chip Seals

• MS
  ▪ Medium Setting
    ▪ Plant Mixing
    ▪ In-place Recycling

• SS
  ▪ Slow Setting
    ▪ Cold Mixes
    ▪ Tack Coats

• QS
  ▪ Quick Setting
    ▪ Slurry Seals
    ▪ Micro Surfacing
**Asphalt Emulsions – Full Classification**

- Identified by numbers and letters related to:
  - Particle charge (prefix)
  - Set rate (prefix)
  - Viscosity of liquid emulsion (suffix)
  - Hardness of base asphalt cements (suffix)

**Hardness + Modification Suffixes**

- No suffix
  - 100-200 pen
- L
  - Latex-modified
- P
  - Polymer-modified
- R
  - Recycling agent-mod.

**Asphalt Emulsion Nomenclature**

- RS-1
- RS-2
- HFRS-2
- MS-1
- MS-2
- MS-2h
- HFMS-1
- HFMS-2
- HFMS-2h
- HFMS-2s
- SS-1
- SS-1h
- QS-1h

**Asphalt Emulsion (ASTM D 977, AASHTO M 140)**

<table>
<thead>
<tr>
<th>Asphalt Emulsion</th>
<th>Cationic Emulsion (ASTM D 2397, AASHTO M 208)</th>
<th>Polymer-Modified Cationic Emulsion (AASHTO M 316)</th>
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<tr>
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<td>RS-2</td>
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<td>CRS-2P, CRS-2L</td>
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<td>QS-1h</td>
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Asphalt Emulsions – Micro Surfacing Classification
- Micro surfacing often specifies CSS-1hP emulsion
  - Meets ASTM and AASHTO CSS-1h requirements
    - With the exception of the cement mixing test
  - Min. polymer content of 3% solids on asphalt
    - Enhances high temperature performance
    - Permits application in multiple stone depths:
      - Rut-filling
      - Leveling operations

Emulsion Application

Asphalt Emulsions – Breaking and Curing
- Breaking/Drying
  - Separation and evaporation of water
- Curing
  - Return of residual asphalt properties
    - Adhesion
    - Durability
    - Water-resistance

Emulsions – Breaking
- Breaking
  - \( \text{H}_2\text{O} \) separating from asphalt phase + evaporating
- Emulsions formulated to break according to app.
- Two breaking mechanisms
  - Chemical
  - Physical or evaporative
**Emulsions - Breaking**

- **Breaking**
  - For SS grades = mechanism mainly evaporation
  - For MS + RS grades = mechanism mainly chemical

**Emulsions - Curing**

- **Curing** – Process whereby mechanical properties of the asphalt return after application
  - Water must completely evaporate
  - Asphalt particles must coalesce and bond to intended surface
  - Water fully removed by evaporation + absorption