

The effects of dusty aggregates towards stripping in asphalt pavements

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What is Stripping ?

"The loss of the bond between the asphalt binder and the aggregate through either a cohesion or adhesion failure caused by the action of water"



What Influences Stripping ?

- Aggregate selection
- Binder selection
- Pavement design
- Mixture design
- Construction
- Drainage
- Additives



Stripping mechanism theories

- Detachment
- Displacement
- Emulsification
- Film rupture
- Hydraulic scouring
- pH instability
- Pore pressure



Detachment

- Microscopic separation of the asphalt film from the aggregate
- Caused by a thin layer of water
- No break in the asphalt film
- Water condensed on aggregate surface through pores or asphalt permeation
- Asphalt film can be peeled off aggregate surface



Displacement

- Similar to detachment
- Asphalt film is removed by water due to a break in the film
- Water enters through pinholes of film rupture



Emulsification

- Asphalt cement forms an inverted emulsion in the presence of water
- Occurs under high traffic on mixtures filled with water
- Can be caused by fines such as baghouse dust and by over-dosage of antistrip additives



Film rupture

- Broken or ruptured asphalt films at sharp aggregate surfaces or due to dust
- Initiates stripping at these points
- Rupture can occur by freeze-thaw, traffic and construction loads
- Allows easy access for water



Hydraulic scouring

- Asphalt film is scoured or removed through the action of traffic and water
- Dust can enhance the occurrence
- "Asphalt is stripped or "scrubbed" off the aggregate



pH instability

- pH at the asphalt aggregate interface
- Acid groups in the asphalt binder
- Acidic aggregates
- Impacts asphalt adhesion
- Affects the wetting characteristics and contact angle at the interface



Pore pressure

- Water present in the pores of aggregate
- Pore pressure causes the asphalt film to strip from the aggregate
- Theory can also apply to the air voids in the HMA pavement becoming saturated with water



Reducing stripping

Strong adhesive bonds reduces the occurrence of stripping or moisture damage



Adhesion theories

- Chemical reaction
- Dispersion
- Mechanical interlocking
- Surface energy



Chemical reaction

- Chemical reaction between aggregate and asphalt consisting of acidic and basic components
- React forming water-insoluble compounds



Dispersion

- Resins surround asphaltenes
- Resins are polar and give adhesive properties to the asphalt
- The dispersion of these resins and asphaltenes have an impact on the asphalt and aggregate interface



Mechanical interlocking

- Surface texture of the aggregate has significant impact on adhesive properties
- Adhesive strength is derived from cohesion in the binder and interlocking properties of the aggregate
- Aggregate absorption, angularity, and surface coating



Surface energy

- Asphalt aggregate interface
- Improve asphalt adhesion by reducing the surface energy on the aggregate
- Influenced by pH, zeta potential, and surface charge



Stripping resistance is a combination of theories



Dusty aggregates

- Aggregate dust coating on the coarse/fine aggregate
- The asphalt binder coats the dust coating and not in contact with the aggregate surface
- Reduced asphalt binder film thickness



Dirty aggregates

- Clay coating (plastic fines) on the coarse/fine aggregate
- The asphalt binder coats the dust coating and not in contact with the aggregate surface
- Reduced asphalt binder film thickness
- Emulsifies the asphalt binder



Plastic fines tests

- Minus 75 µm content (washed gradation)
- Sand equivalent
- Plasticity index (Atterberg limits)
- Methylene Blue value



Gradation

- Minus 75 micron
- Particle size or grain size distribution

Percent

Particle size



Particle size

- Silt-clay: < 75 microns
- Silt: 2 microns to 74 microns
- Clay: 1 microns to 2 microns
- Colloids: < 1 microns



Sand equivalent test

- ASTM D2419
- Graduated cylinder separating the clay particles from the sand particles
- Height of sand and clay is measured
- The sand equivalent value is the ratio of the sand height to the clay height (%)
- > 40 %



Plasticity index

- ASTM D 4318 or AASHTO T90
- Determine the liquid limit and plastic limit of the minus 425 μ m content
- Plasticity index is the liquid limit value minus the plastic limit value
- < 4 %



Methylene blue value

- ISSA technical bulletin 145, measures clay content
- Add a solution of methylene blue dye to a sample of minus 75 µm until saturated
- Visual determination of the "end point" observed on filter paper
- Reported as the amount of methlyene blue per gram of minus 75 µm
- The higher the value, the greater the amount of clay in the sample



Studies

 Kandhal, Lynn and Parker, "Tests for Plastic Fines in Aggregates Related to Stripping in Asphalt Paving Mixtures", NCAT Report 98-3