



Getting the Most from Chip Seals

Understanding Chip Seals



- Benefits and Limitations
- Design and material selection
- Proper construction methods/techniques
- Variations
- Types of failures and causes

"Chip seal is the application of an asphalt binder to a pavement surface which is covered by a layer of one-sized, preferably crushed, cubical, aggregate"



Benefits



- Seal and protect age-oxidized surfaces
- Provide durable, high-friction wearing surfaces
- All-weather performance, used in multiple climate zones in U.S.
- Seal and resist reflection of small surface cracks
- Provide a waterproofing layer at the surface which protects the underlying pavement structure
- Cost-effective preventive maintenance and pavement preservation, extends life of pavements

Limitations



- Predominately for Low and Medium Volume Roads
- Susceptible to Snow Plow Damage
- Limited Construction Season
- Less margin for construction error- Loose Chips and Bleeding
- Consumer Acceptability

Design and Material Selection



Four Basic Steps

- Pavement Survey
- Mix design
- Binder Selection & Application Rate
- Aggregate Selection & Application Rate

Pavement Condition Survey



Mix Design & Job Mix Formula



Job mix formula determined by

- Pavement surface condition
- ADT of roadway or highway
- Gradation and type of aggregate
- Emulsion Type
 - Anionic or Cationic
 - Modified or Non-Modified
- Weather conditions
 - Temperature
 - Humidity
 - Wind
 - Sunlight
 - Rain Forecast

Pavement Conditions for Success



- Structurally Sound
- Defects Patched and Cured
- Surface must be clean and free of loose stone and debris
- Surface must be dry
- Pavement temperatures
- No Impending Rain forecast for 24Hrs

Single Chip Seal



Pavements with bituminous surface

- Light cracking
- Moderate cracking with crack fill
- Light to moderate raveling
- Polishing
- Light to moderate flushing
- Good ride quality & structural soundness

Double Chip Seal



Pavements with bituminous surface

- Moderate cracking
- Severe cracking with crack fill
- Moderate to severe raveling
- Light to moderate Bleeding or Flushing
- Good ride quality & Structural Soundness

Binder Selection



•Rapid-Setting Emulsion

- Can be used with Damp Aggregates
- Low or no VOC- Environmentally Friendly!
- Modified or Non-Modified
- Anionic or Cationic

•Asphalt Cement

- Requires Hot Spray at Elevated Temperatures
- Pre-coated Stone

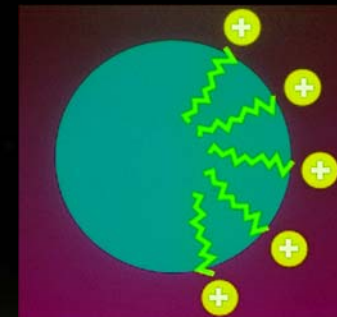
•Solvent Cutbacks

- Flammable and Combustible Liquids
- VOC Emissions

What is an Asphalt Emulsion?



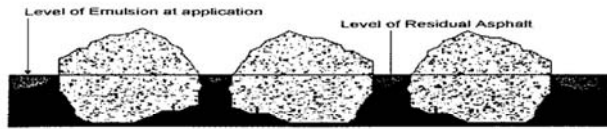
“An Asphalt Emulsion is a chemically-stabilized dispersion of fine asphalt particles throughout a continuous phase of water as a carrier”



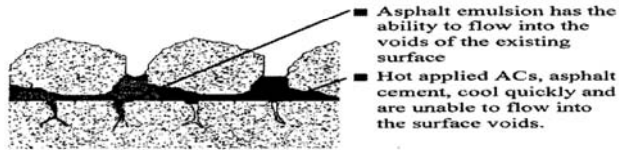
Why Emulsions are Better



Asphalt Emulsion Allows Greater Contact with the Cover Stone.



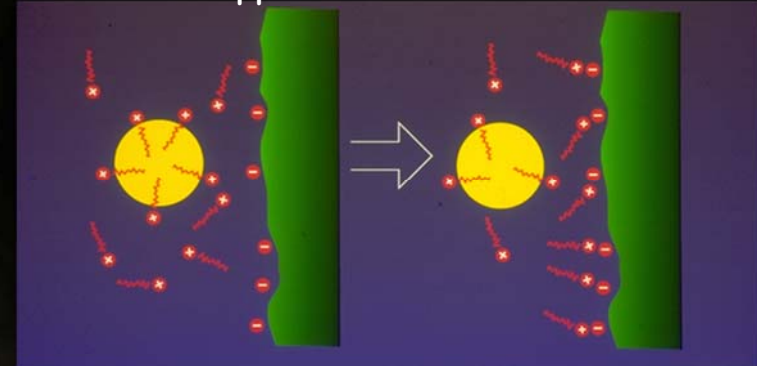
Emulsion Penetrates Cracks & Surface Voids.



Aggregate Effect



Opposites Attract !



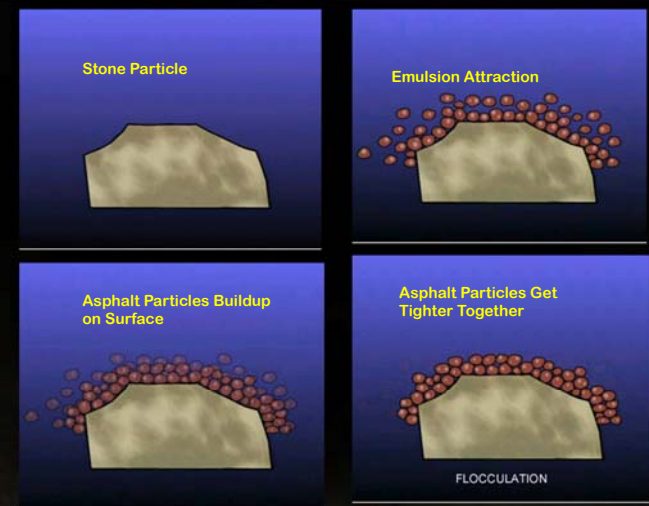
Particle Charge of the surfactant surrounding the Asphalt Droplets is attracted by the particle charge on the Aggregate Surface

Cationic or Anionic?



Material	Cationic emulsion	Anionic emulsion
Electropositive materials (calcium, basalt)	Neutralizing reaction <div>BREAKING</div> forming of insoluble amine carbonate <div>ADHESIVENESS</div>	attraction <div>BREAKING</div> forming of insoluble calcium soap <div>ADHESIVENESS</div>
Electronegative materials (silex, quartz, granite)	attraction <div>BREAKING</div> forming of insoluble amine silicate <div>ADHESIVENESS</div>	no neutralizing reaction no attraction

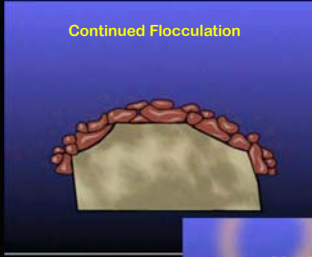
Emulsion Aggregate Interaction Process



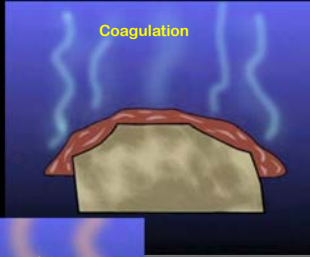
Emulsion Aggregate Interaction Process



Continued Flocculation



Coagulation



Film Cure Occurs thru evaporation of residual water and solvents

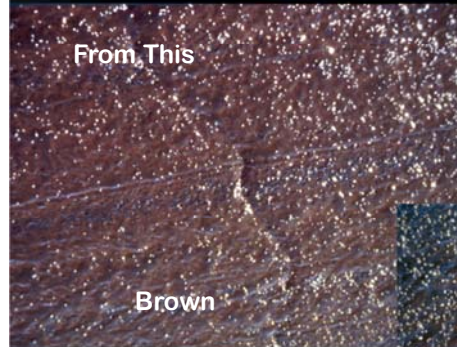


SFERB Emulsion Book

Emulsion Breaking



From This



Brown

To This



Black

Why Asphalt / Aggregate Choice is Important to a Successful Job?



Poor adhesiveness gravel/binder



Poor cohesiveness



**“Degree of Job Success is not measured
By the number of Broken Windshields!”**

Aggregate Selection



- One Sized Aggregate (Recommended Size Chart)
- Cubic Particle Shape (Crushed Stone)
- Sound Material, resistant to abrasion and degradation
- May use pre-coated (mainly for hot spray asphalt binder)
- Follow ASTM D1139 for Soundness Guidelines
- Choice will determine type of asphalt emulsion used

ASTM D1139 Specifications



- LA Abrasion (ASTM C131) <40%
- Percent Fractured Faces(ASTM D5821) >60%
 - 2 faces minimum
- Sodium Sulfate Soundness (ASTM C88) <12%
- Magnesium Sulfate Soundness <18%
- Flat or Elongated Pieces(ASTM D4791) <10%
- Deleterious Materials (ASTM C142) <3%
- Density Aggregate Specific Requirement

Application Rates



- ASTM D1369 Guidelines
- AI/AEMA MS-19 Handbook Guidelines



or



Application Rates



Table 6.3 Quantities of Asphalt and Aggregate for Single Surface Treatments^{1,2,3,4}

Nominal Size of Aggregate	Size No.	Quantity of Aggregate kg/m ² (lb/yd ²)	Quantity of Asphalt l/m ² (gal/yd ²)	Type and Grade of Asphalt*
19.0 to 9.5 mm (3/4 to 3/8 in.)	6	22-27 (40-50)	1.8-2.3 (0.40-0.50)	RS-2, CRS-2
12.5 to 4.75 mm (1/2 in. to No. 4)	7	14-16 (25-30)	1.4-2.0 (0.30-0.45)	RS-1, RS-2, CRS-1, CRS-2
9.5 to 2.36 mm (3/8 in. to No. 8)	8	11-14 (20-25)	0.9-1.6 (0.20-0.35)	RS-1, RS-2, CRS-1, CRS-2
4.75 to 1.18 mm (No. 4 to No. 16)	9	8-11 (15-20)	0.7-0.9 (0.15-0.20)	RS-1, MS-1, CRS-1, HFRS-2
Sand	AASHTO M-6	5-8 (10-15)	0.5-0.7 (0.10-0.15)	RS-1, MS-1, CRS-1, HFRS-2

* Including polymer modified versions of these emulsions

¹ These quantities of asphalt cover the average range of conditions that include primed granular bases and old pavement surfaces. The quantities and types of materials may be varied according to local conditions and experience.

² The lower application rates of asphalt shown in the above table should be used for aggregate having gradations on the fine side of the specified limits. The higher application rates should be used for aggregate having gradations on the coarse side of the specified limits.

³ It is important to adjust the asphalt quantity for the surface condition of the road, increasing it if the road is absorbent, badly cracked, or coarse, and decreasing it if the road is flushed with asphalt. (See table below.)

⁴ It is important to adjust the asphalt quantity for traffic count and conditions. An increase in traffic will mean a decrease in asphalt content.

Correction for Surface Condition

Pavement Texture	Correction** L/m ²	Correction** (gal/yd ²)
Black, flushed asphalt	-0.04 to -0.27	(-0.01 to -0.06)
Smooth, non-porous	0.00	(0.00)
Absorbent - slightly porous, oxidized	0.14	(0.03)
- slightly pocked, porous, oxidized	0.27	(0.06)
- badly pocked, porous, oxidized	0.40	(0.09)

**This correction must be made from observations at the job site.

Adjustments?



- Surface Conditions
- Traffic Volumes / Types
- Type and Specific Gravity of Aggregates
- Aggregate Size
- Pre-coating
- Local Experience
- Laboratory Determinations – Pan Test

9 Step Construction Process



- Set traffic control and prepare surface removing debris and loose stone with power broom
- Adjust spray bar to correct height and nozzles to proper angles
- Calibrate distributor and chip spreader
- Spray test strip, strap distributor to determine volume available
- Spray binder at correct volume to pavement surface
- Spread aggregate immediately behind
- Roll immediately with pneumatic roller
- Allow to cure
- Sweep excess aggregate



Computer Controlled Asphalt Distributor



Today



Operators Bar Control



Material Metering and Control System

Asphalt Distributor



- Hydrostatic controls maintain material application rate regardless of ground speed
- Spray widths from 1 to 24 feet, without stopping
- Eliminates matching pump output to ground speed
- Proper bar height and nozzle angle minimizes longitudinal seams

Some Things Never Change!



Two Mule Power Distributor



Same Basic Design

Proper Bar Adjustments

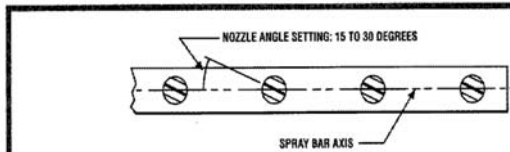


Figure 6.6 Proper Nozzle Angle Setting

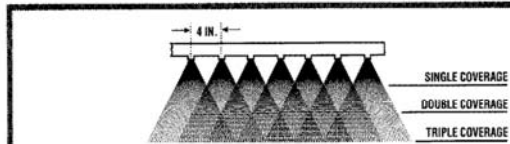
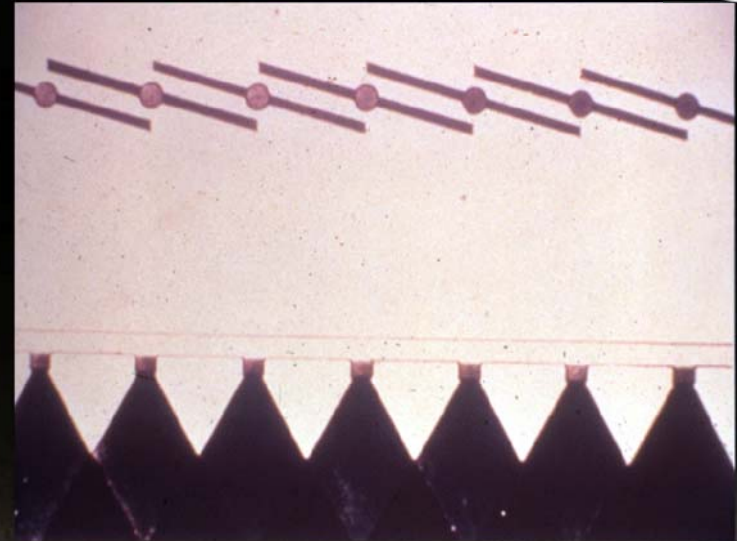


Figure 6.7 Spray Bar Height Must Be Set Exactly for Proper Coverage

Fan Pattern and Angle Overlap



Chip Spreader



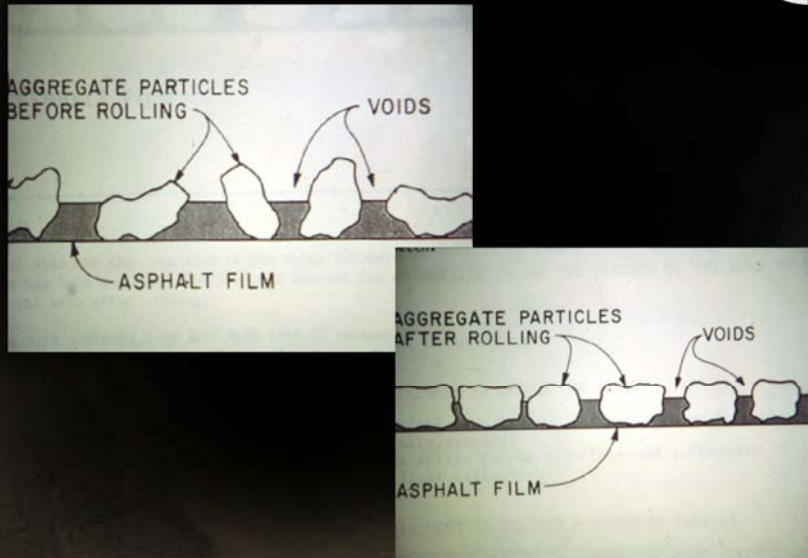
Maintain correct speed to prevent rolling
Proper adjustment of gates imperative

Rollers



- Pneumatic tire rollers follow directly behind spreader
- Control speed to avoid chip displacement
- One to five passes may be used, two to four sufficient to embed chips properly with correct orientation on surface
- Last pass in direction of traffic

Proper Rolling Results



Power Brooms

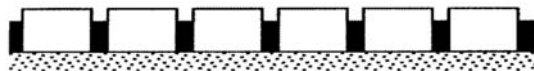


- Clean pavement prior to and after chip seal
- Pickup-type sweepers used in areas where materials can not be moved onto an aggregate shoulder.

Doing Things Right



Average Least Dimension 0.5 in.
Asphalt 0.39 gal/yd²
Cover Aggregate 49 lb/yd²



Average Least Dimension 0.2 in.
Asphalt 0.16 gal/yd²
Cover Aggregate 20 lb/yd²

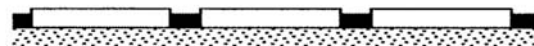
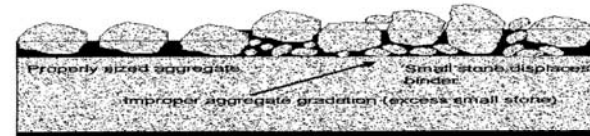


Fig.2 Illustrating the effect of aggregate particle shape on materials quantities. Both aggregates are 0.5 inch as measured by sieve analysis. One is cubicle, the other is flat and elongated. Voids filled is 70% for both aggregates.

Effects of Improper Gradation



Effects of Improper Aggregate Gradation



Results of Improper Aggregate Gradation



Preparation



- Patches and Cold Mix Leveling need proper cure times
- If necessary, Fog Seal may be used to seal patch areas
- Crack fill carefully, excessive filler can be a problem
- Smooth patches result in smoother ride
- Ideal to perform prep work previous season

Address Base Failures



Address Rutting



Troubleshooting



- Streaking
- Flushing/Bleeding
- Aggregate Loss
- Joint Raveling
- Ride Quality

Streaking



Figure 6.8. Spray bar is too high (ridges)

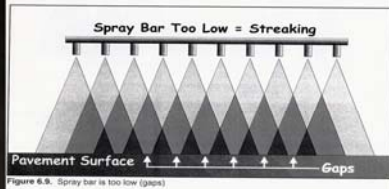


Figure 6.9. Spray bar is too low (gaps)

MinnDOT Seal Coat Handbook

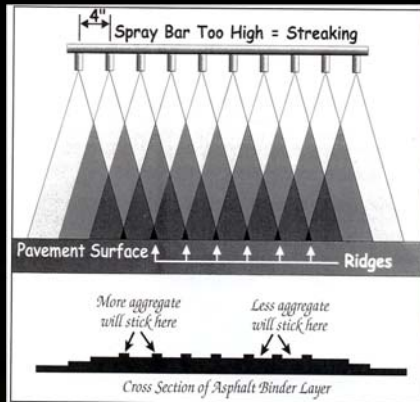


Figure 7.2. Schematic of incorrect spray bar height

Longitudinal Streaking



Usually results from Poor Spray Pattern or faulty gate control in spreader box.

Transverse Streaking

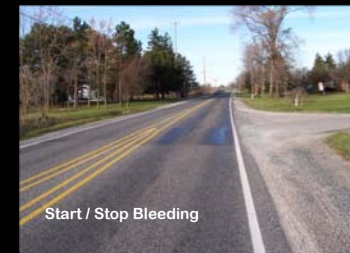


Usually from irregular progress of Chip Spreader or chatter in spreader box

Flushing, Bleeding, & Fat Spots



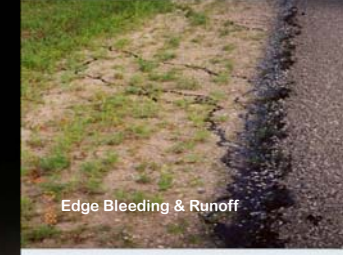
Wheel Path Bleeding



Start / Stop Bleeding



Fat Spot Bleeding



Edge Bleeding & Runoff

Common Preventions



Level Rutting



Start Stop Strips



Pickup Droppings & Slop



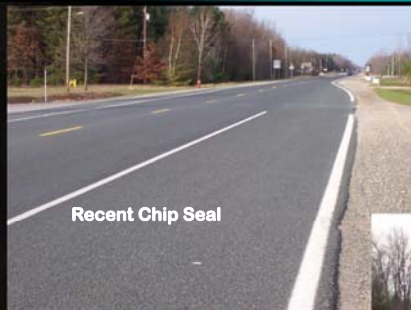
Control Application
Rate, Temperature,
Emulsion Viscosity,
And Aggregate Moisture

Polymer Modifiers ?



- RS-2P, HFRS-2P, CRS-2P are common grades
- Use SBS, SBR, or EVA as common modifiers
- Provide increased cohesion for better early chip retention
- Higher softening points lower potential for bleeding
- Provide higher degree of crack retardation
- Must be carefully selected and formulated by Supplier
- Stability can be an issue if not formulated properly

Quality Chip Seals



Recent Chip Seal



Two-Year old Chip Seal

QUESTIONS?

