The Chip Seal Process and Why we do it that way

Standard Chip Seal:
Spray Emulsion Binder, Drop the Chips, Roll 3 times, let it cure overnight, Sweep away the excess

Key Elements of the Process

- **Design (McCleod)**
  - **Application rates**
  - **Rock Requirements**
- **Rolling**
- **Using Choke**
- **Fogging**
- **The Importance of time and when to seal**

  - **Don't forget the road needs to be prepped and clean**

Why do a chip seal design before starting

- Proper chip embedment is critical to seal success
  - Too little and we loose rock
  - Too much and we flush loosing skid resistance
- Chip embedment is affected by binder application rate as well as traffic load and road condition.
- A good chipseal design will give you the right emulsion and aggregate rates to give the seal proper chip embedment

Reference Sources

- **Chip Seal Design Program**
  http://www.dot.state.mn.us/materials/researchsealcoat.html

- **Minnesota Seal Coat Handbook**
  http://www.lrrb.org/pdf/200634.pdf

Chip Seal Design Method

- What should this design method do?
  - 1. Give amount of aggregate needed to cover 1 sq. yd² a single stone thick (Extra is wasted)
  - 2. Give starting binder application rate
    - Starting rate would yield approximately 70% embedment
    - Must adjust for current conditions of pavement
      - Recommendations for the crew to use to help adjust for different traffic levels and pavement conditions

Tests run on Aggregate for design

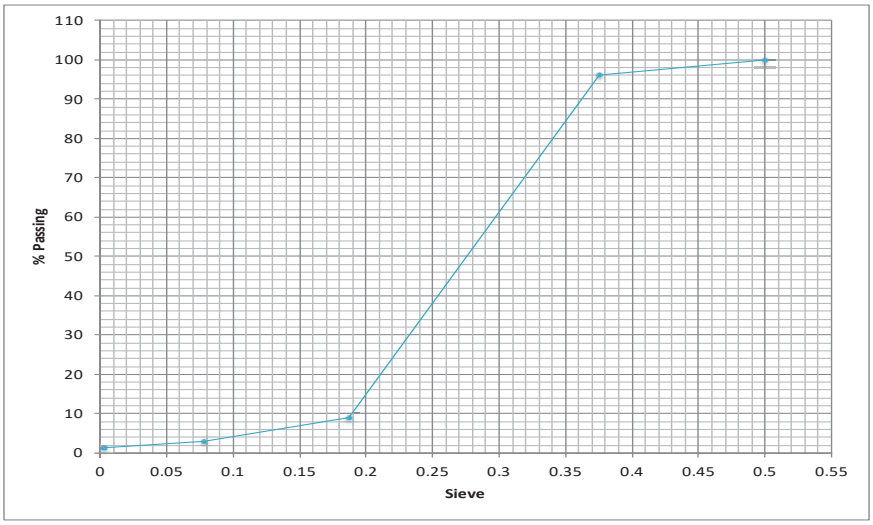
- Gradation – Binder ; for embedment
- Loose Unit Weight – To Calc. Voids / room for binder
- Specific Gravity – To Calc. Voids
- Absorption – Binder; for loss in absorb.
- Flakiness Index- Binder; for functional embedment. How high will the chips sit up when finally embedded.

Precision is the Key to Success

- The higher the number of sieves used to grade the material the more accurate the design.
- The more cubical the rock the more precise the design.
- Accurate traffic count.
- Accurate Road evaluation.

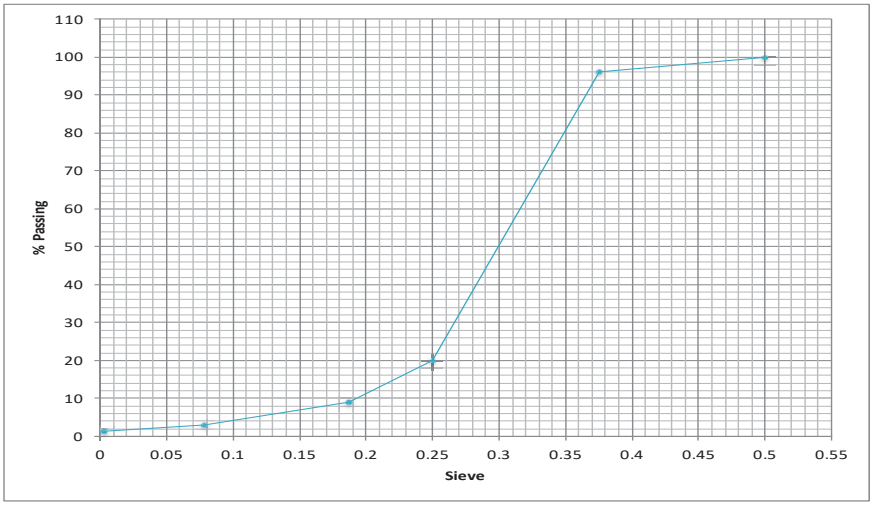
This grading shows 0.275 In median size

	Sieve	Passing
1/2	0.5	100
3/8	0.375	96
4	0.187	9
10	0.0787	3
200	0.0029	1.3



Adding one more sieve increases accuracy
Median is more accurately shown to be 0.3 in.

	Sieve	Passing
1/2	0.5	100
3/8	0.375	96
1/4	0.25	20
4	0.187	9
10	0.0787	3
200	0.0029	1.3



Know Your Pavement Condition

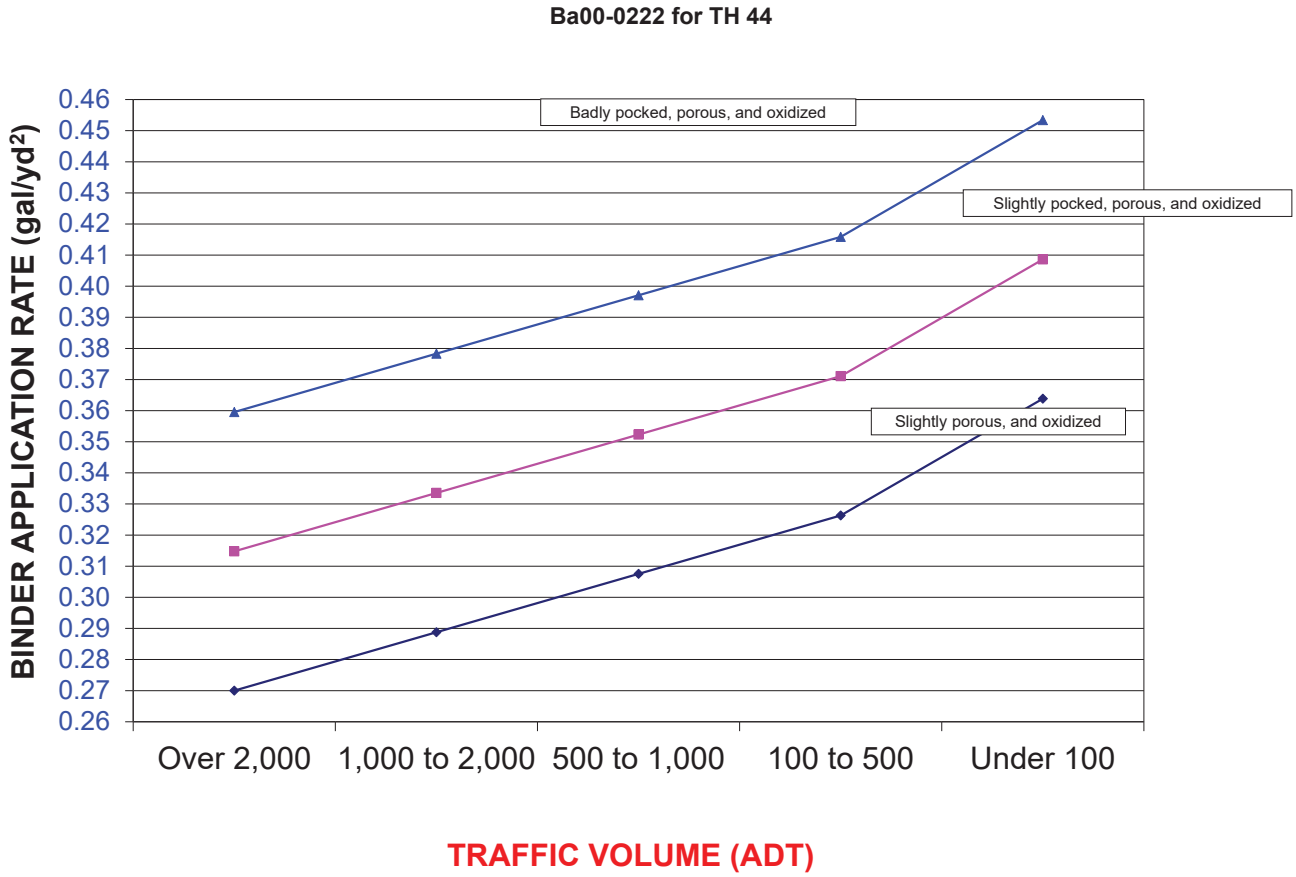
"Flushed Pavement" vs. "Badly Pocked Porous and Oxidized" and everything in between

We need that Traffic Count

- We need the traffic count on the roads to be sealed
- Higher traffic compacts rock more
- Lower traffic compacts rock less
- Just like we need that info for hotmix paving

McLeod Emulsion Calculation

- B(G/SqYd)=((2.244 x Ave Least Dimension x Traffic Factor x Voids in loose Agg) + Surface Condition factor + Agg Absorb Factor) / Residual Asphalt Content of Binder . For Wheel Paths
- Then same calc on Median Rock Size instead of Average Least Dimension. For Non Wheel Paths
- Average the two.
- Only need calc on Median Rock Size if rock is very cubical.
- May not need to average if we can improve non - wheel path embedment. - Later in talk!



H	Ave Least Dimension - Median Rock Size		0.294			Flakiness ratio		0.9	0.294	
T	Traffic Factor		-100 ADT	0.85	100-500	0.75	500-1000	0.7	1000-2000	0.65
V	Voids in loose Agg		Single Chip	0.5						
S	Surface Condition		Smooth, non porous	0	Slightly porous & oxidized	0.03	Slightly pocked porous & oxidized	0.06	Badly pocked porous & oxidized	0.09
A	Agg Absorption		None	0						
R	Residual AC Cont		0.665							
100 ADT on Badly Pocked & oxidized										
Binder Appl Rate =		0.557	Gal/yd2	2.244	0.294	0.85	0.5	0.09	0	
						0.665				
100 ADT on Slightly pocked, Porous & oxidized										
Binder Appl Rate =		0.512	Gal/yd2	2.244	0.294	0.85	0.5	0.06	0	
						0.665				
100 ADT on Slightly Porous & oxidized										
Binder Appl Rate =		0.467	Gal/yd2	2.244	0.294	0.85	0.5	0.03	0	
						0.665				
100 ADT on Smooth non-porous										
Binder Appl Rate =		0.422	Gal/yd2	2.244	0.294	0.85	0.5	0	0	
						0.665				
00-500 ADT on Badly Pocked & oxidized										
Binder Appl Rate =		0.507	Gal/yd2	2.244	0.294	0.75	0.5	0.09	0	
						0.665				

Standard Chip Seal Aggregate Requirements

- Must be clean - For reliability
  - Less then 1% passing #200 sieve; better adhesion
- Durable - wear life
  - LAR, lower = harder, polish / wear resistant
- Flakiness Index - reliability
  - Lower = More cubicle, uniform shape easier to design around. More accurate design = More reliable seal.

- Single sized Chips
  - More uniformed height
  - Has more room for binder – Space not filled by smaller aggregate particles.
  - The more single sized the easier it is to develop a good chipseal design.

9-03.4 Aggregate for Bituminous Surface Treatment

9-03.4(1) General Requirements

Aggregate for bituminous surface treatment shall be manufactured from ledge rock, talus, or gravel, in accordance with Section 3-01, which meets the following test requirements:

Los Angeles Wear, 500 Rev.	35% max.
Degradation Factor	30 min.

9-03.4(2) Grading and Quality

Aggregate for bituminous surface treatment shall conform to the requirements in the table below for grading and quality. The particular type or grading to be used shall be as shown in the Plans. All percentages are by weight.

The material shall meet the requirements for grading and quality when placed in hauling vehicles for delivery to the roadway, or during manufacture and placement into a temporary stockpile. The exact point of acceptance will be determined by the Engineer.

Crushed Screening Percent Passing					
	¾"-½"	⅝"-No. 4	½"-No. 4	⅜"-No. 4	No. 4-0
1"	99-100				
¾"	95-100	99-100			
⅝"		95-100	99-100		
½"	0-20		90-100	99-100	
⅜"	0-5		60-85	70-90	99-100
No. 4		0-10	0-3	0-5	76-100
No. 10		0-3			30-60
No. 200	0-1.5	0-1.5	0-1.5	0-1.5	0-10.0
% fracture, by weight, min.	90	90	90	90	90

All percentages are by weight.

The fracture requirement shall be at least one fractured face and will apply to the combined aggregate retained on the No. 4 sieve in accordance with FOP for AASHTO T 335.

The finished product shall be clean, uniform in quality, and free from wood, bark, roots, and other deleterious materials.

Crushed screenings shall be substantially free from adherent coatings. The presence of a thin, firmly adhering film of weathered rock shall not be considered as coating unless it exists on more than 50 percent of the surface area of any size between successive laboratory sieves.

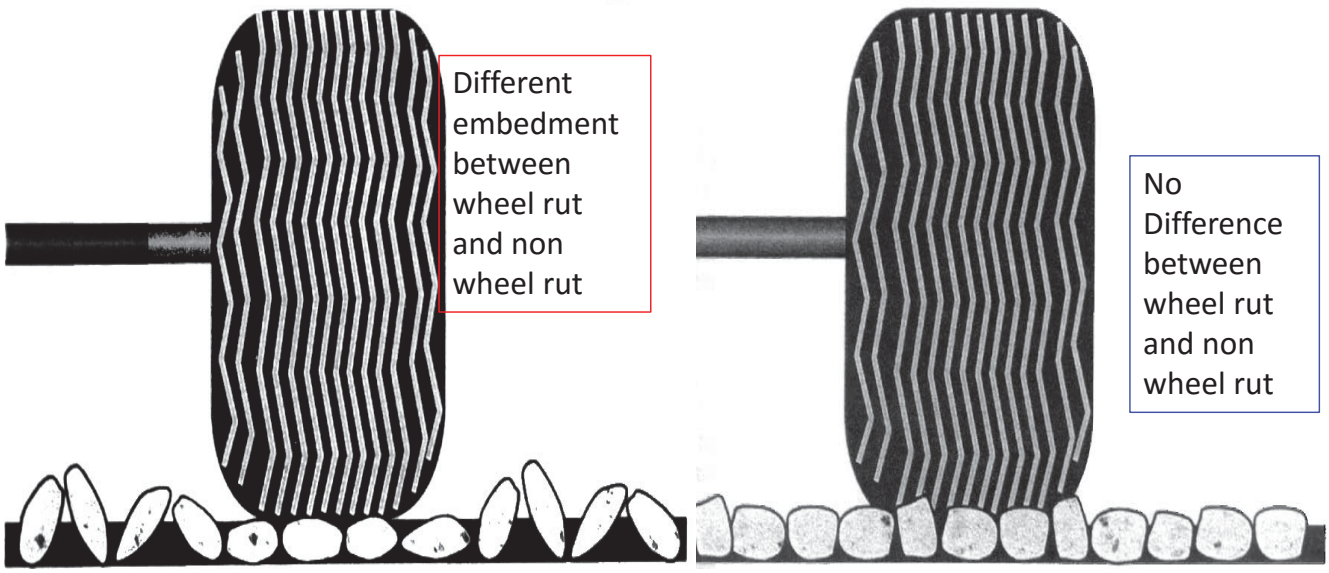
The portion of aggregate for bituminous surface treatment retained on a No. 4 sieve shall not contain more than 0.1 percent deleterious materials by weight.

Fine aggregate used for choke stone applications meeting the grading requirements of Section 9-03.1(2)B may be substituted for the No. 4-0 gradation.

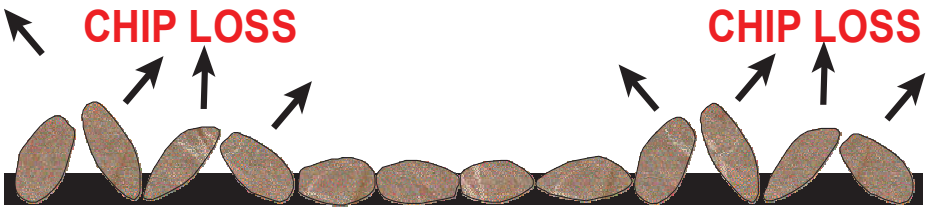
Aggregate Application Rate Calc

- Need - Ave least Dimension
- Need - Specific Gravity of the Aggregate
- Calculate the Voids in Loose Agg
  - V= (Loose unit weight (lbs/cubic ft)/(62.4*Spec Gravity)
- Wastage factor Example 10% for high traffic, 5% for very low slow traffic 1+.10 = 1.10 high Traffic
- C (Appl Rate) = 46.8* (1-(0.4)*Voids in loose Agg*Ave Least Dimension*Specific Gravity *Wastage Factor for Traffic whip off

The Problem with Flat Chips

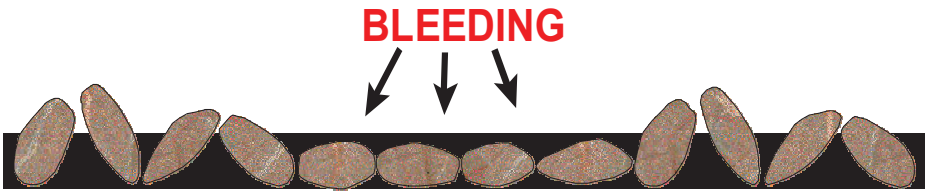


If the seal coat is designed for chips in the wheelpaths:



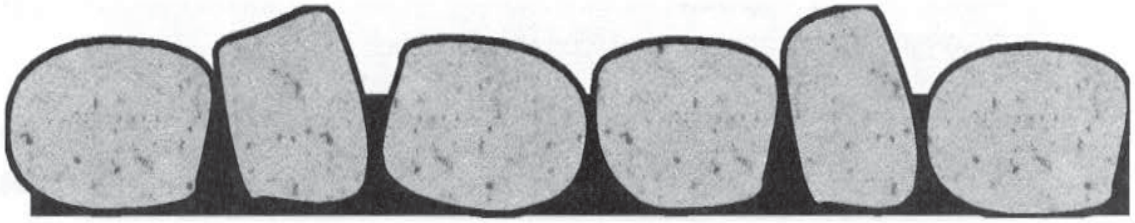
There is not enough binder in the non-traffic areas to prevent traffic and snow plows from dislodging the chips.

If the seal coat is designed for chips in the non- traffic areas:



There is too much binder in the wheelpaths after the flat chips lay on their flattest side.

Single Size vs. Graded Aggregate



Single Sized Aggregate Perfect for the standard chip seal with CRS-2P, CMS-2P Plenty of room for binder. (Adhesive)

Graded Aggregate / Not good for CRS-2P or CMS-2P
Great for Otta Seal / Maintenance Seal with HF -150
Less room for binder, Relies on rock interlock

CRS-2P, CMS-2P

- Polymer Emulsions
- Stiffer binder - reduces bleeding
- Develops strength faster than other emulsions, can sweep sooner.
- Requires clean chips
- Must place chips immediately
- Most Expensive conventional chipseal emulsion

9-02.1(6)A Polymerized Cationic Emulsified Asphalt CRS-2P

CRS-2P shall be a polymerized cationic emulsified asphalt. The polymer shall be milled into the asphalt or emulsion during the manufacturing of the emulsified asphalt. CRS-2P shall meet the following requirements:

	AASHTO Test Method	Specifications	
		Minimum	Maximum
Viscosity @122°F, SFS	T 59	100	400
Storage Stability 1 day %	T 59		1
Demulsibility 35 ml. 0.8% Dioctyl Sodium Sulfosuccinate	T 59	40	
Particle Charge	T 59	positive	
Sieve Test %	T 59		0.30
Distillation			
Oil distillate by vol. of emulsion %	T 59[1]	0	3
Residue	T 59[1]	65	
Tests on the Residue From Distillation			
Penetration @77°F	T 49	100	250
Elastic Recovery %	T 301[2]	50	

[1]Distillation modified to use 300 grams of emulsified asphalt heated to 350°F ± 9°F and maintained for 20 minutes.
[2]The residue material for T 301 shall come from the modified distillation per note 1.

Why is rolling critical?

- When the rock is dropped into the binder the voids will approach 50%
  - At this level of voids the chip is not stable enough to withstand traffic and will ravel
- Rolling will drop that to around 30%
  - At this level of voids the chip is stable enough to withstand light traffic but not plowing and high traffic
- The final product to be achieved in the design will not occur until the voids are down around 20%
  - This usually does not occur without a lot of post construction traffic but each successive pass of the rollers over a seal under construction helps to move the seal to the final

Need more rolling

- While the wheel paths get the compaction needed for a successful seal
- Parking lanes, Fog line, Turn lanes, Qtr Crown, Center Line area, etc. do not.
- Traffic will take much longer to give these areas the compaction needed per the design.
- Give it extra attention while building (Give them extra Rolling)
- Add a STEEL roller

Steel Rollers

- Being used successfully by WSDOT, ODOT and many counties.
- Add it to the fleet, don't just replace a pneumatic. More rollers are always better.
- If it bridges the low points don't worry.
- The high points aren't getting enough traffic for embedment. Steel will help.

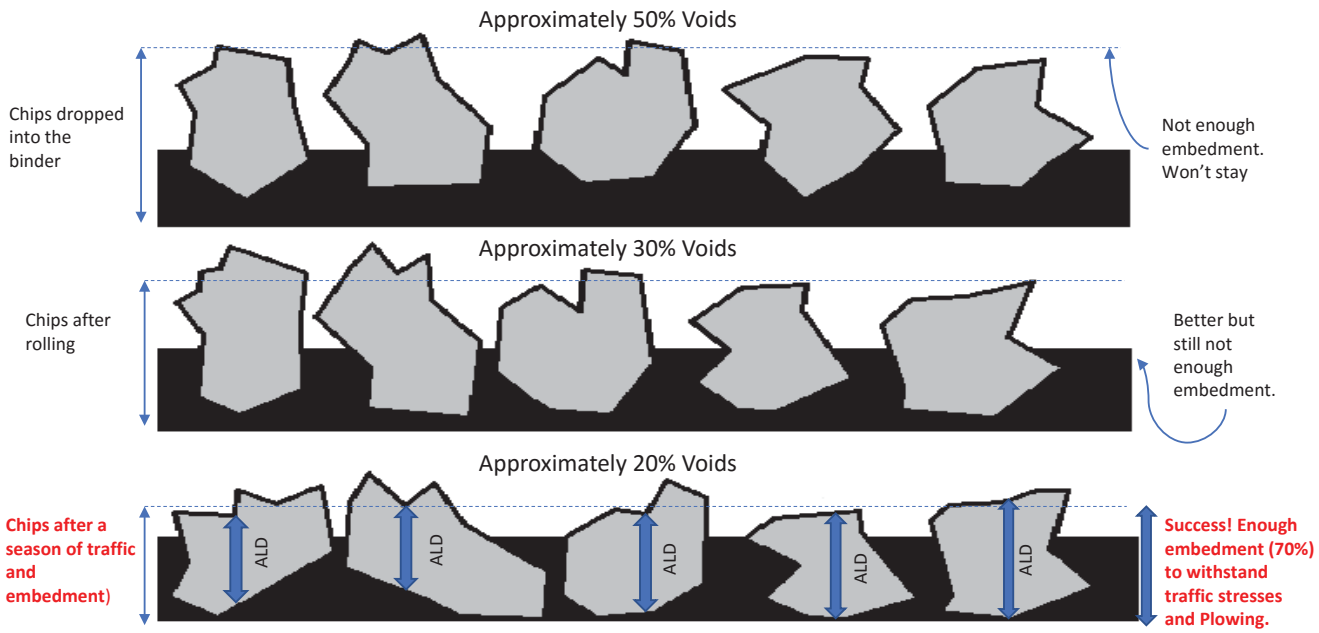
– Steel immediately improves embedment, Cuts plow damage.

- Run the Steel Roller in static mode, vibe is not needed to orient and compact chips.

38,000 lb. Vibratory Roller
Bonner County, Idaho

Note the Effect on the Aggregate Texture

Why we roll / Why we go early



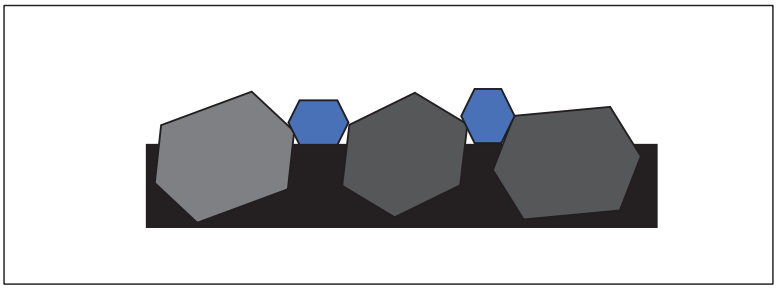
Why you should chip seal early in the season

- A chip seal needs Time to fully cure:
  - 160 hours pavement temp exceeding 110 F
  - The warmth is needed to soften the binder residue so that the final few percent of water that is trapped in the seal can work its way out
  - This means even with a good design if the seal is done late in the season the final product will not be achieved until the next season.
  - The earlier the better!! Let the warm weather help traffic finish the seal
    - Late seals often don't reach final voids and most stable chip embedment and may not have released all their water making them susceptible to raveling and Plow damage.

Sealed in Sept. on Shady Road. Emulsion did not cure, just stiffened. Peeled off under traffic. Section in full sun looks great.

Holes left by late season water vaper escaping the seal in the following season

Why we use Choke aggregate



- Choke acts as a blotter forming a barrier between vehicle tires and any exposed emulsion from the seal.
  - Don't use too much or too dirty that may not allow water vapor to escape the seal and delay curing
- Choke helps to keep the chips from rolling around
  - The choke aggregate wedges in between the chips
  - Those chips can't turn over which would expose fresh emulsion and cause the seal to track
- Choke helps the emulsion break
  - Emulsion wants to break when it makes contact with rock

Fog Sealing: Benefits over chipseal

- Extra Security against chip loss – Add'l emulsion residue
- Help in post construction traffic embedding action
  - Black color increases pavement temp to soften residue for improved embedment from traffic. Extends window to cooler days
- Aesthetics – black like new pavement

Fog Sealing

- .12 to .14 gal/yd^2 on chip seals
- .08 to .10 gal/ yd^2 on pavements
- Loss of skid resistance is a concern over dense pavements
  - Use of Sand is good temporary fix
- Recommended emulsions are CSS-1 or 1H Dil, Rapid Setting fogs, etc.

Fog Sealing has benefits beyond Chip Seal use

- TRB Paper 08-0632, Fog seals are cost effective
- Seal pavement against water/oxidation
- Reduce hardening - Flexibility of Pavement
- Reduce / delay deterioration - Maintain Texture
- Need to be applied early in pavement life
  - Start within 1 to 2 years of paving
- No or little visible cracking
- Fog wears off surface but stays in matrix.
  - Review of 4 yr. old fog seals show the seal effects still present. Retarding water infiltration

I -90 After First Winter
Was much tighter when new

Fresh fog
Filling voids – sealing against water and air infiltration

Points to remember

- Do your sealing early in the season (You need cure time)
- Do a design / Understand the size and cleanliness of your rock, the condition of the road and traffic count.
- Roll, Roll, Roll
- Add that steel roller
- Remember to compensate for new mats, open pavements, shady areas. They need more emulsion / Extra Rolling