The Chip Seal Process

And why we do it that way

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Standard Chip Seal:

1. Spray emulsion binder
2. Drop chips
3. Roll 3 times
4. Let cure overnight
5. Sweep away excess

Key elements of the process

- Design (McCleod)
  - Application Rates
- Rock Requirements
- Rolling
- Using choke
- Fogging
- The importance of time, temperature and traffic

Don’t forget the road needs to be prepped and clean

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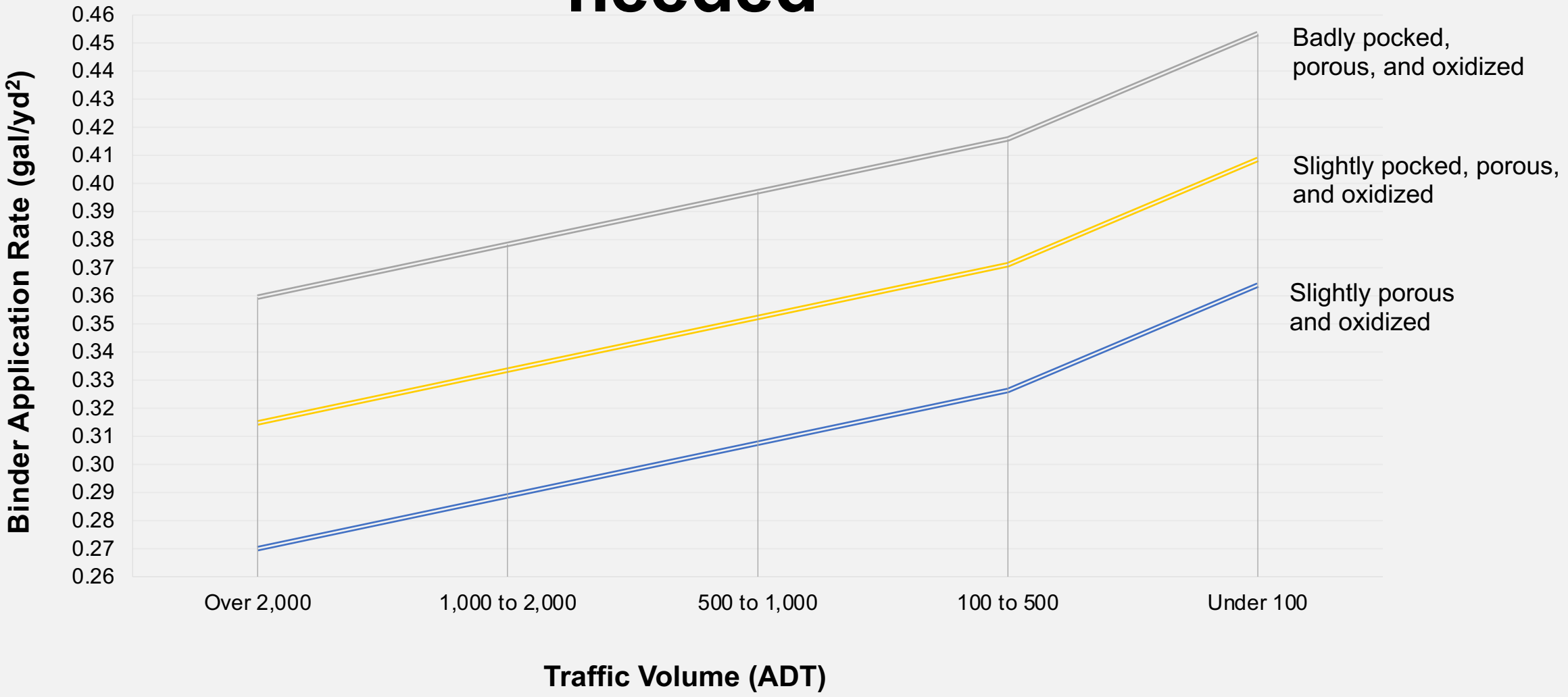
Why do a Chip Seal design before starting?

- Proper chip embedment is critical to seal success
  - Too little and we lose rock
  - Too much and we flush, losing skid resistance
- Chip embedment is affected by binder application rate as well as traffic load and road condition
- A chip seal design gives you the right emulsion and aggregate rates
- It gives you an understanding of the effects that changing traffic and road conditions will have on your application rate
- This cuts out the guessing

Traffic and Road Condition have a huge effect on binder volume needed



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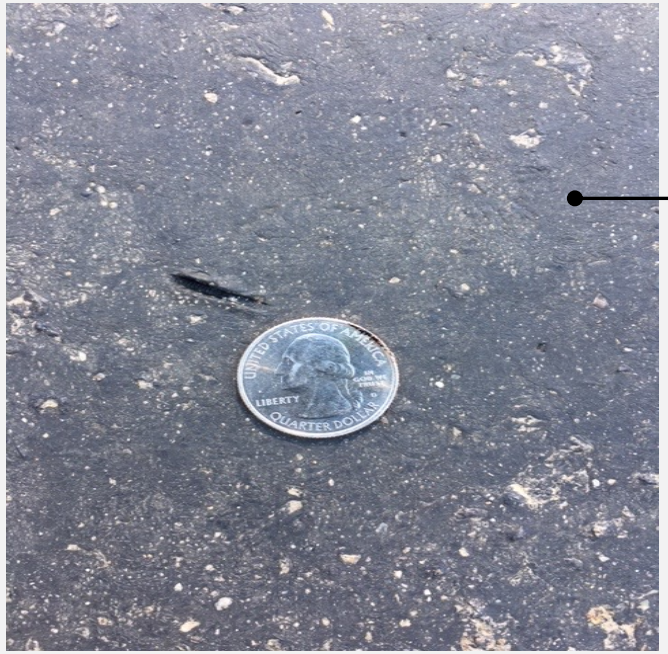
Know your pavement condition

Flushed pavement vs. badly pocked, porous and oxidized
(and everything in between)



Won’t absorb any of the binder

Will absorb a lot of the binder

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ODOT Test Section 2019

This design is for reference only. Field adjustments are necessary. Design done from one sample supplied by the customer and may vary due to stockpile variations, errors in sampling, etc.

H	**Ave Least Dimension**	**Median Rock Size**	0.244			**Flakiness Ratio**		0.9	0.244	
T	**Traffic Factor**		**-100 ADT**	0.85	**100-500**	0.75	**500-1000**	0.7	**1000-2000**	0.65
V	**Voids in Loose Aggregate**		**Single Chip**	0.5						
S	**Surface Condition**		**Smooth, Non-porous**	0	**Slightly Porous and Oxidized**	0.03	**Slightly Pocked, Porous and Oxidized**	0.06	**Badly Pocked, Porous and Oxidized**	0.09
A	**Aggregate Absorption**		None	0.018						
R	**Residual AC Cont**		0.67							

-100 ADT on Badly Pocked and Oxidized

Binder Appl Rate at 60°C =	0.509	Gal/yd^2	2.244	0.244	0.85	0.5	0.09	0.018	
					0.67				
Hot Binder Rate at 165°F	**0.528**								

-100 ADT on Slightly Pocked, Porous and Oxidized

Binder Appl Rate at 60°C =	0.464	Gal/yd^2	2.244	0.244	0.85	0.5	0.06	0.018	
					0.67				
Hot Binder Rate at 165°F	**0.481**								

-100 ADT on Slightly Porous and Oxidized

Binder Appl Rate at 60°C =	0.419	Gal/yd^2	2.244	0.244	0.85	0.5	0.03	0.018	
					0.67				
Hot Binder Rate at 165°F	**0.435**								

-100 ADT on Smooth Non-porous

Binder Appl Rate at 60°C =	0.374	Gal/yd^2	2.244	0.244	0.85	0.5	0	0.018	
					0.67				
Hot Binder Rate at 165°F	**0.388**								

Aggregates

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Standard Chip Seal aggregate requirements

- Single sized
- Must be clean – for reliability
  - Less than 1% passing #200 sieve; better adhesion
    - ✓ **Dust grabs the binder before the rock can**
- Durable – wear life
  - LAR, lower = harder, polish/wear resistant
    - ✓ **Reduces stud and traffic wear**
- Flakiness Index – reliability
  - Lower = More cubicle, uniform shape easier to design around
    - ✓ **More accurate design = more reliable seal**
- Fractured faces – Stability on the road

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.

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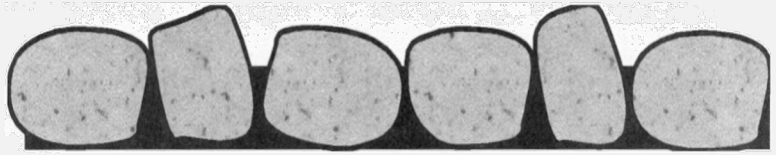
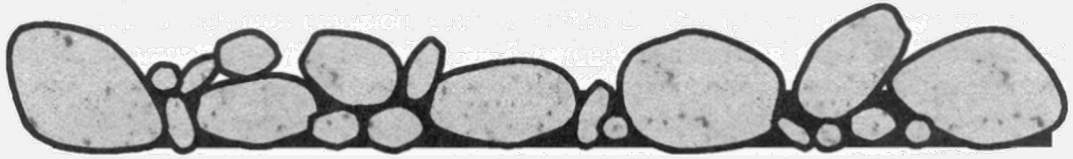
Single size vs. graded aggregate



Single sized aggregate is perfect for the standard chip seal with rapid cure emulsions (CRS-2P)

More uniform 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 chip seal design



Graded aggregate is not good for CRS-2P or CMS-2P

- Will flush the little rock and may not hold the big rock
- Fines may block the binder from reaching the big rock
- Great for Otto Seal or maintenance seal using slower breaking HFE-150

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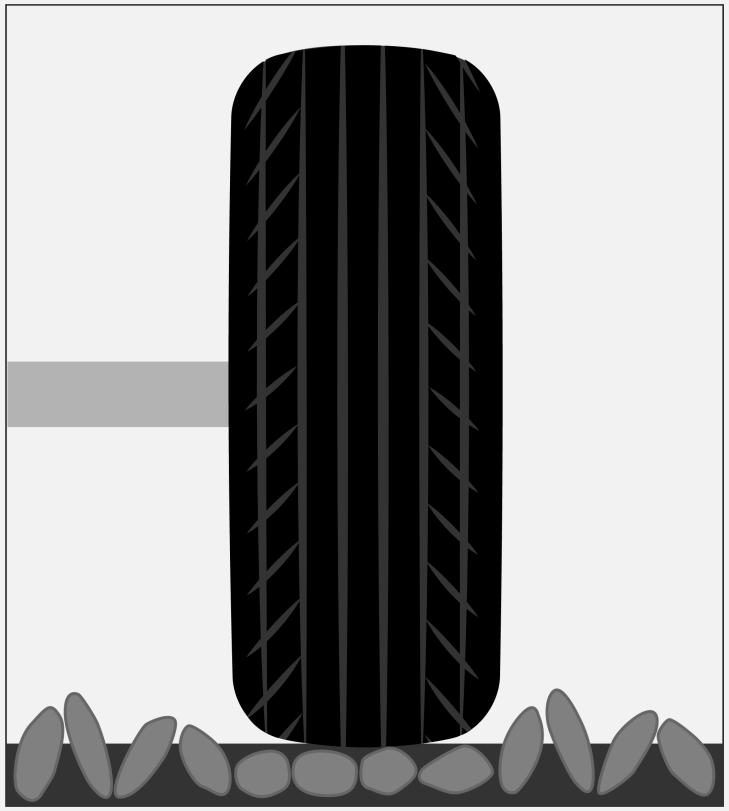
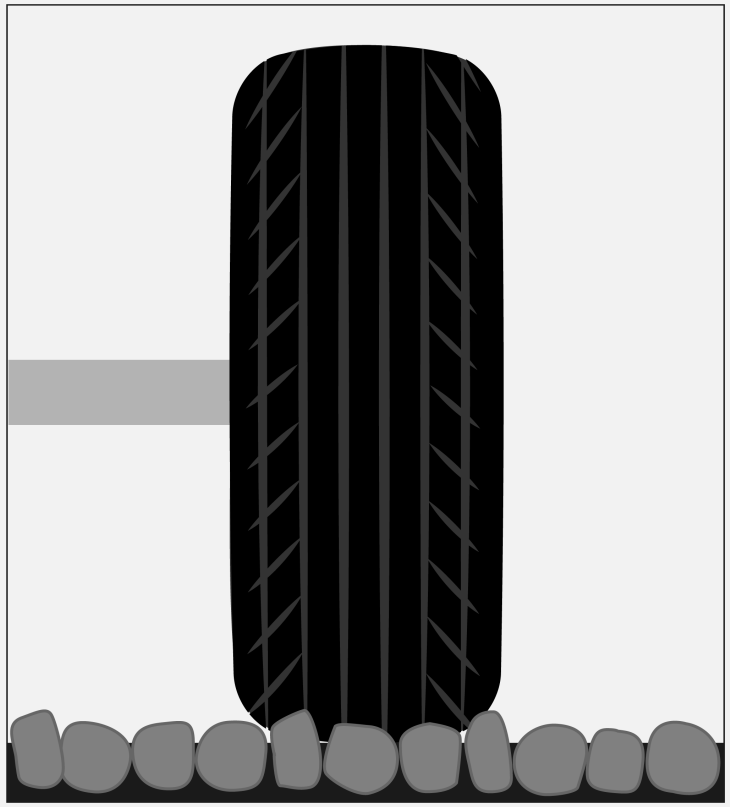
The problem with flat chips





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The rock needs to be damp

- Rapid breaking emulsions start to break as soon as they find aggregate, usually it’s the dust
- Water on the rock slows the break on the emulsion giving more time for the emulsion to get to the chip
- Water on the rock helps pull the emulsion through the dust layer

Binders

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CRS-2P, CMS-2P, CRS-2LM, CRS-2R

- Polymer-containing emulsions
- Polymer acts like glue enhancing the grab on the rock
  - The polymer does not make the emulsion elastic!
- Develops strength faster than other emulsions, can sweep sooner
- Requires clean chips
- Requires damp rock
- Must place chips immediately
- Most expensive conventional chip seal emulsions due to the polymers

New – “CVRS-2P”

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What is really important!

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.

Rollers

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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 they already get compaction
- The high points aren’t getting enough traffic for embedment, steel will help
- Steel immediately improves embedment and cuts plow damage

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38,000 lb. Vibratory

Bonner County, Idaho

Any steel wheel roller works:
double drum, grade, big, small

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Note the effect on the aggregate texture

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Areas that need more rolling

- While the wheel paths get the compaction needed for a successful seal
- **Parking lanes, fog line, turn lanes, quarter crown, centerline area, etc. do not**
- Traffic will take much longer to give these areas the compaction needed per the design
- Give them extra attention while building; increase the emulsion application rate slightly and give them extra rolling
- The higher the traffic count the bigger disparity between the travel area and Parking Lanes, fog line, turn lanes, quarter crown, centerline area, etc. May need to increase application in these areas if possible

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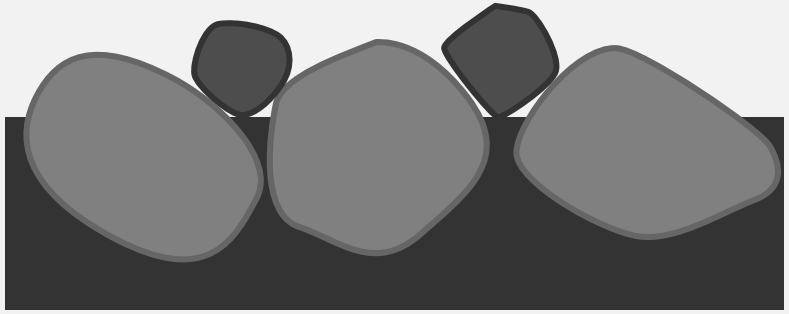
Why we use choke stone

- Choke keeps traffic out of the oil
- Choke helps to keep the chips from rolling around
  - It wedges in between chips, they don’t turn over, keeping the seal from tracking
- Choke helps the emulsion break
  - Emulsion wants to break when it makes contact with any rock



Fog Seal

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Why we Fog Seal a fresh Chip Seal

- Additional emulsion residue
- Black color increases pavement temperature
  - Higher temp helps traffic increase rock embedment. 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 a good temporary fix
- Recommended emulsions are CSS-1 or CSS-1H Dilute, “Quickseal”, rapid setting fog oils, etc.

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Fog Seal has benefits beyond Chip Seal use

- TRB Paper 08-0632, fog seals are cost effective
- Seal pavement against water/oxidation
- Reduce hardening – helps keep flexibility in the pavement
- Reduce/delay deterioration – maintain texture
  - Start within 1 to 2 years of paving
- Fog wears off surface but stays in matrix
  - Review of 4 year old fog seals show the seal effects still present – retarding water infiltration


I-90 after first winter
(it was much tighter
when new)

Fresh Fog

Filling voids – sealing against water and air infiltration


Final product looks like new pavement to the public

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There is more to having a successful chip seal than having a good design

After you've placed the seal it needs the 3 Ts:

1. **Temperature:** Warm temperatures to soften the residue
2. **Traffic:** Enough traffic traveling over the seal to finish embedment
3. **Time:** To get the seal completely compacted before warm summer temperatures end

The more you can count on one of these, the less you worry about the others

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Temperature

Pavement temperature exceeding 110°F

- 110°F is close to the softening point of the binder
- Need warm temperatures to change the emulsion residue to a smooth film from separate particles as they were when the binder was still suspended in the emulsion
- The softened binder is necessary to allow traffic to work the seal for embedment and to knead the last few % of water trapped in the residue out of the system
- This means even with a good design, if the seal is done after all the warm weather is gone, the rock won't be fully embedded and may retain water going into the plow season
- If the road is shaded you will not get adequate road temperatures
- The earlier the better!! Let the warm weather help traffic finish the seal

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Temperature of the same road in the shade and in the sun

Air temperature at 2 PM is 80°F

Shaded area: 87.2°F

Sunny area: 115°F

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The shade effect

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Traffic

- When the rock is dropped into the binder, the voids will approach 50%
- Rolling will drop that to around 30%
- The final product to be achieved in the design will not occur until the voids are down around 20%
- **This has to be achieved by a lot of post construction traffic**

  Wheels on the road!
- If you don’t have enough traffic, the voids won’t decrease and the chips will not reach the design embedment
- Possible seal failure risk until final embedment/voids are reached

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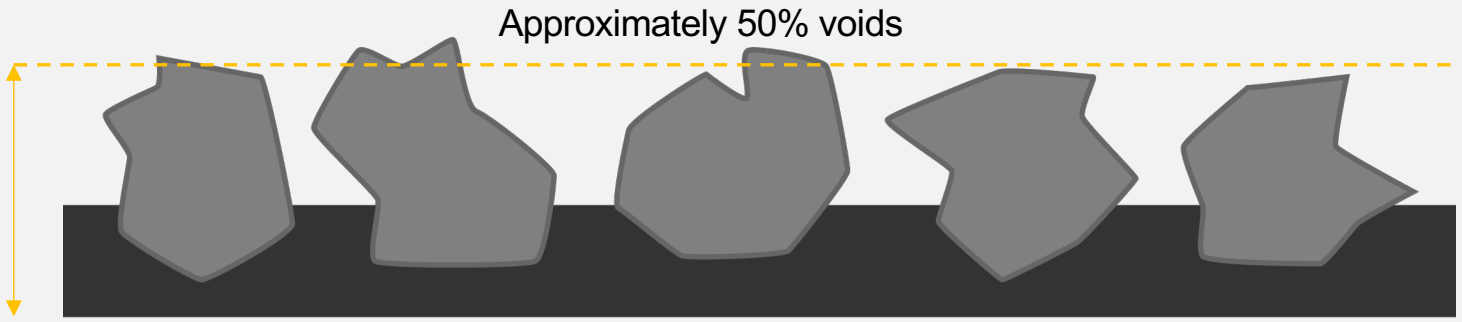
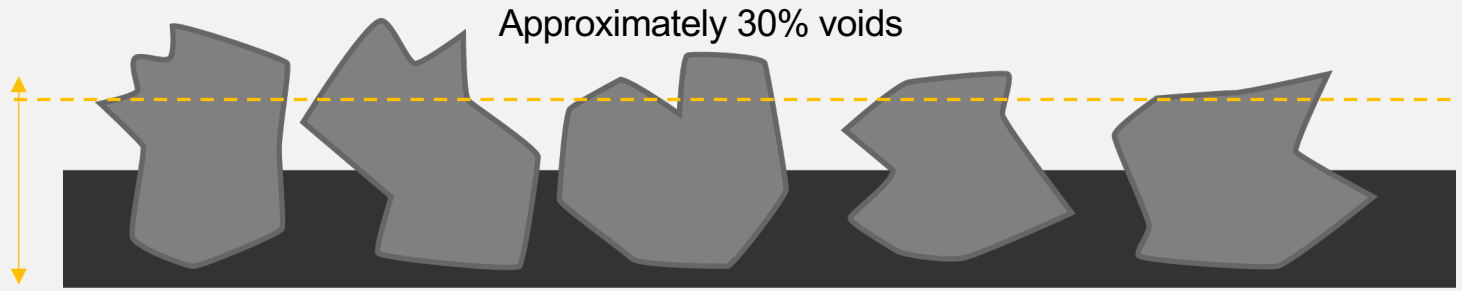
The stages of chip embedment

Chips dropped into the binder



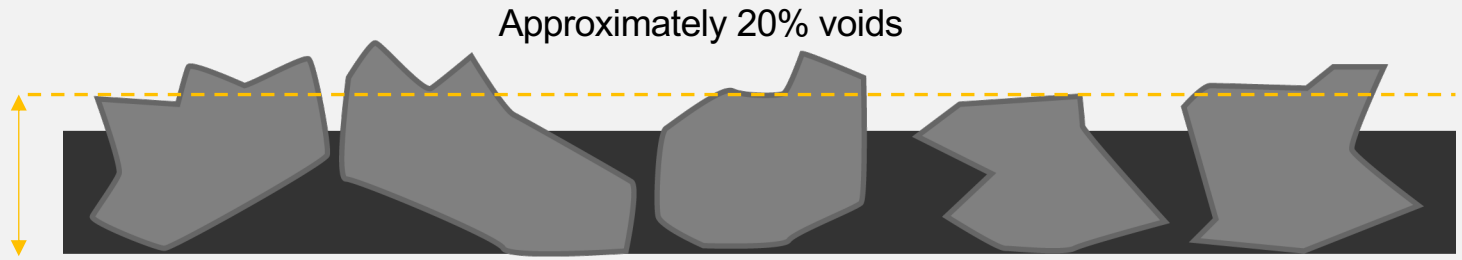
Not enough embedment. Won't stay.

Chips after rolling



Better but still not enough embedment.

Chips after traffic (orientation and embedment)



Success! Enough embedment to withstand traffic stresses and plowing.

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Time

- Low-volume roads need more time to get enough traffic
  - **100 ADT county roads need a lot of warm weather days to complete embedment**
    - They need to be done early so there are wheels on the road on every hot day
    - Need more time before end of season
- High-volume roads achieve the traffic levels fast
  - **Freeways and 2000 ADT roads will get enough wheels within a few days to a week when temperature is achieved to complete embedment**
    - They can be sealed later in the summer
    - Need less time before end of season

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Chip Seal Problems?

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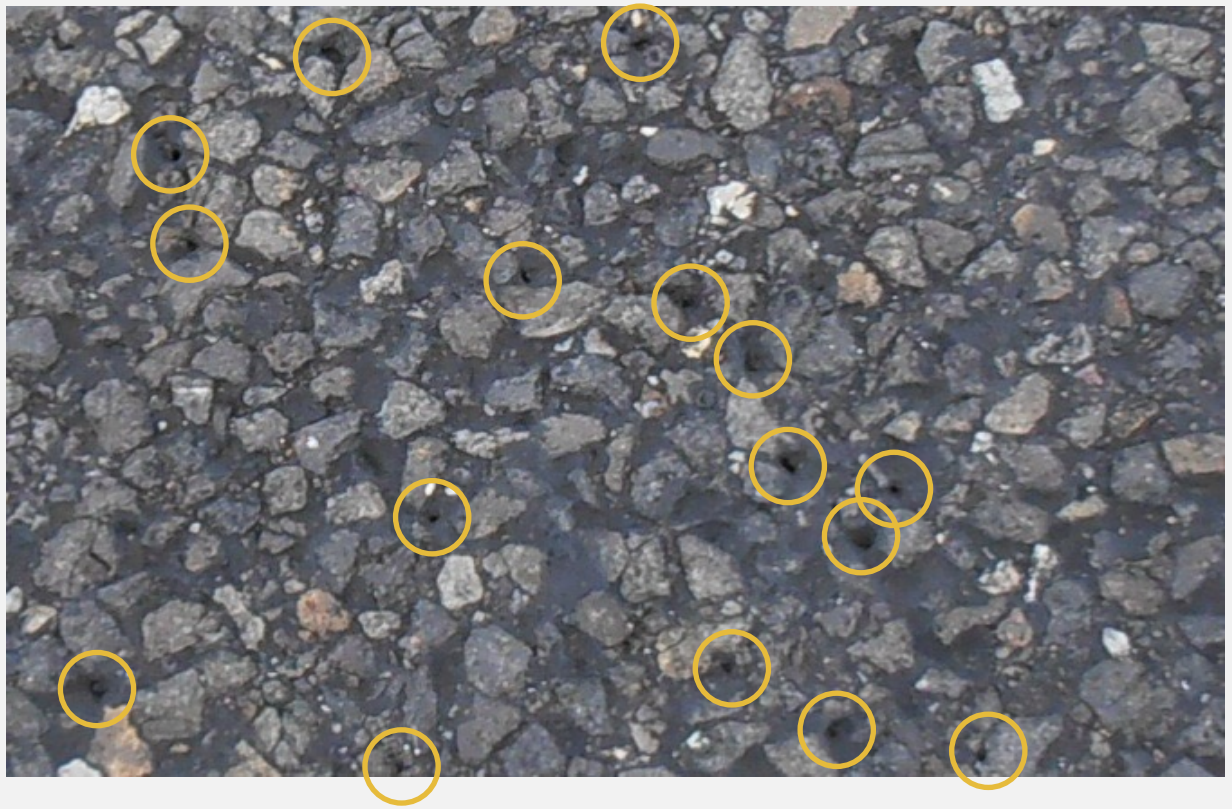
Holes left by late water vapor



Seal was done too late to get rid of trapped water before winter

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Too much dirty choke

- Late season
- Water could not evaporate
- It pooled and drained out

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Road never dries out

- Probably not a good seal candidate for any type of seal, emulsion or hot (notice the moss)
- Cold temperatures
- This road never gets to temperature- Never!

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Sealed in September on a shady road. Emulsion did not cure, it just stiffened. Traffic could not embed further. Peeled off under traffic. Further down the section in full sun looks great.

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No traffic, no seal

High traffic with double stripe

- No traffic crossed the centerline
- Needed extra rolling attention

This was a hot-applied chip seal

- They are less responsive to traffic for final embedment due to higher residue softening point
- Has had some issues in northern states

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Rock picking out

Could be dirty rock
or low shot rate

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Flushing in the wheel paths

Shot rate too high for the level of traffic on this road

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What can make a Chip Seal fail?

1. Heavy rain or overly wet surface
2. Cool temperatures
3. Dirty rock
4. Over choking/choke too dirty
5. Sealing late in the season
6. Low shot rate
7. High shot rate
8. Not enough rolling
9. Not prepping patches
10. Not accounting for shade (Needs extra binder)

2 out of 10 = 50% chance of failure
3 out of 10 = 100% chance of failure

Special technique for Chip Seals

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FA-2 Chip Seal specs

“.25 inch Chip Seal”

- CRS-2P .30 gal/yd^2
  - Application at the higher end holds multi layers of rock for finer surface, more surface correction
- FA-2 (.25 inch) rock 15 to 20 lbs/yd^2
  - Will sweep off a good percentage (retains about 11 lbs) but need to place initially to absorb/account for all the CRS-2P
  - Retain the rock swept off to use going forward – the rock is expensive, and this technique requires a lot of extra rock
- Rapid curing fog emulsion .1 to .15 gal/yd^2
  - Extra insurance and gives a final appearance like pavement
- End result is a seal that looks much like a Type II Slurry and is more accepted on residential streets

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High Float Emulsion and Crushed Cover Stone

"Otto Seal" – Report 1989

- Use HF-150 and Crushed Cover Stone vs. ½ to ¼ and CRS-2P
- Crushed Cover Stone has high fracture and is fully graded like hot mix rock (Rock keys in on itself)
- Application rate is .40 to .46 gal/yd^2 vs. .55+ gal/yd^2 for CRS-2P
- Apply approx. 35 lbs of DRY Crushed Cover Stone
  - This dense graded material will bridge in the chipper otherwise
- Very reliable because we get both binder and rock interlock to hold these seals in place

“Otto”/Crushed Cover Stone Seal

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Points to remember for success

- Do a design – understand the size and cleanliness of your rock, the condition of the road, and traffic count Use previous years for comparison.
- Match your seal construction to your conditions
  - Sunny and warm climate – early to late **You have Temperature**
  - High traffic – early to late **You have Traffic**
  - Shade or colder climate – early only **You have Time**
    - **If you're going late, paint it black and use the sun's heat**
    - **If you're nervous, paint it black and add some residue**
- Roll, roll, roll **You can't over roll**
- Add that steel roller
- Remember to compensate for new mats, open pavements, shady areas – they need more emulsion and/or extra rolling

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Thank you

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