Chipseal Design and Materials

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Western States Asphalt

Discussion Topics

- Mcleod Chipseal Design (Mndot version)
- Aggregate Requirements
- Binders
- Alternative to a Chipseal
  - Maintenance Seal
- Review of Spokane's FA-2 Seals

Chipseal Design Method

- What should this design method do?
  - 1. Give amount of aggregate needed to cover 1 sq. yd^2 a single stone thick
  - 2. Give starting binder application rate
    - Starting rate would yield 60% to 70% embedment if no absorption by pavement
    - Must adjust for current conditions of pavement
      - Recommendation for crew to use to help adjust for traffic and conditions of pavement

Design

- Design is based upon a single rock source / sample
  - Each rock source needs a design Do not assume two sources meeting the same spec are close enough.

- Takes into account traffic effects
  - The higher the traffic the more compaction the surface gets and the lower the binder content to hold the rock and vice versa.
- Takes into account road surface conditions
  - The rougher the road the more binder it going to be absorbed into the surface so more binder is needed to have enough left to hold the chips.

Reference Source

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

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

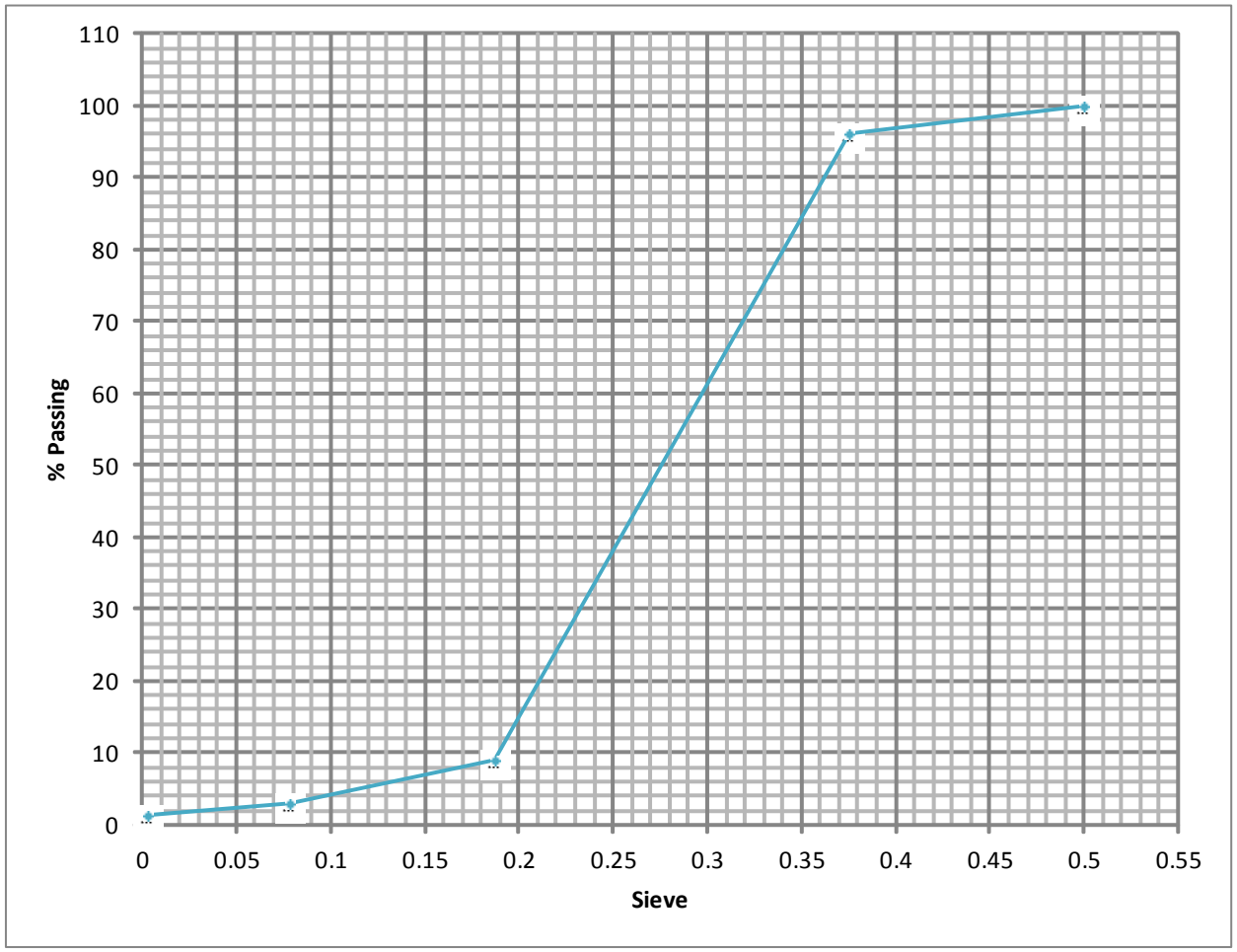
McLeod Emulsion Calculation MNDOT Version

- 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.

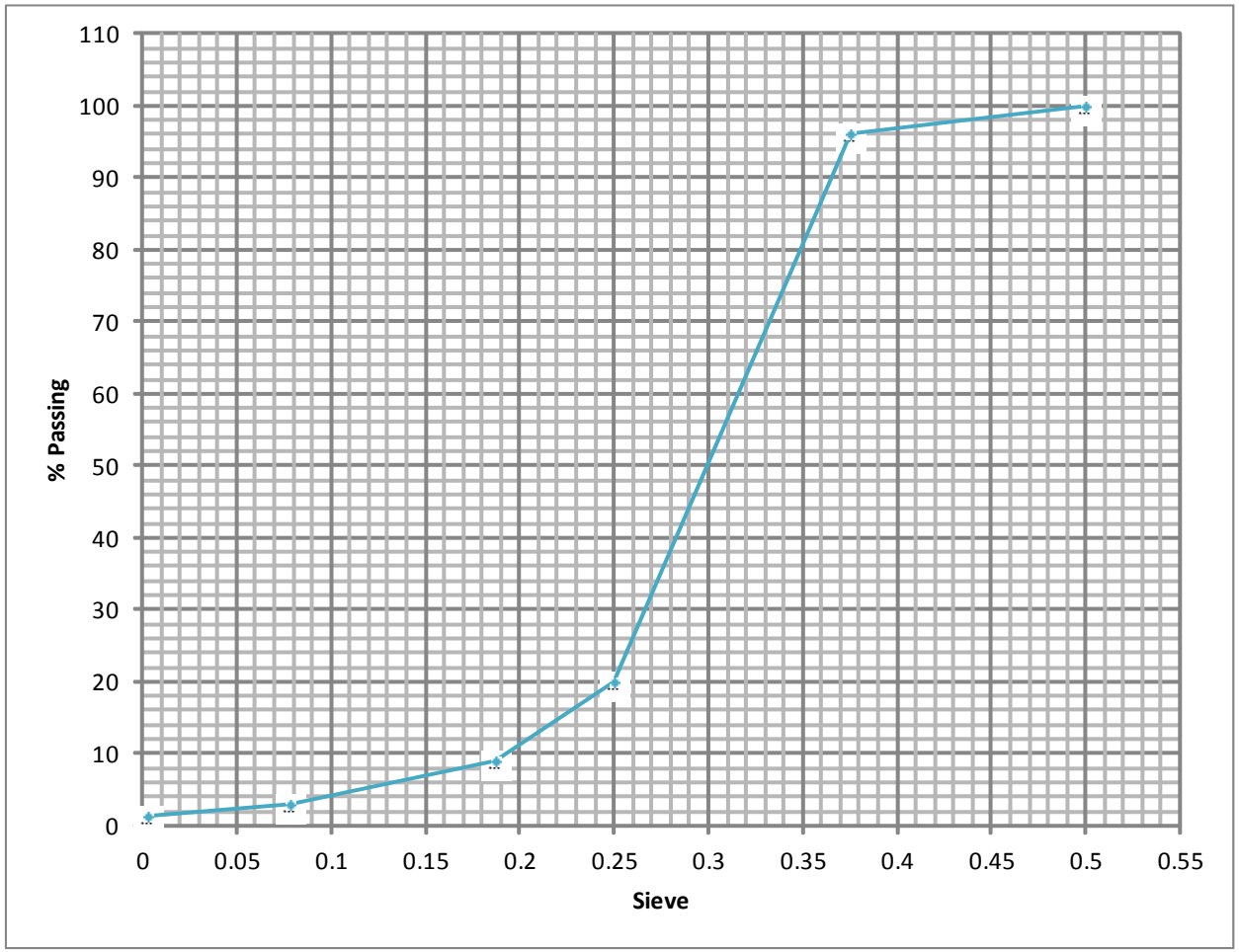
Precision is the Key to Success

- 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.

	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



	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



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.

Project Name:	Flora Pit 2011

This Design is for reference only. Field adjustments are necessary. Design done from 1 sample supplied by the customer and may vary due to stockpile variations, errors in sampling etc.

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				

200-500 ADT on Badly Pocked & oxidized

Let's make it a less cubical

Project Name: **Flora Pit 2011**

This Design is for reference only. Field adjustments are necessary. Design done from 1 sample supplied by the customer and may vary due to stockpile variations, errors in sampling etc.

H	**Ave Least Dimension**	**Screen with 1st. 20% Retained**	0.294			**Flakiness ratio**	0.8	0.2646			
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 =	0.515	Gal/yd2	2.244	0.2646	0.85	0.5	0.09	0	
					0.665				

-100 ADT on Slightly pocked, Porous & oxidized

Binder Appl Rate =	0.470	Gal/yd2	2.244	0.2646	0.85	0.5	0.06	0	
					0.665				

-100 ADT on Slightly Porous & oxidized

Binder Appl Rate =	0.425	Gal/yd2	2.244	0.2646	0.85	0.5	0.03	0	
					0.665				

Now higher Agg. Absorption

Project Name: **Flora Pit 2011**

This Design is for reference only. Field adjustments are necessary. Design done from 1 sample supplied by the customer and may vary due to stockpile variations, errors in sampling etc.

H	**Ave Least Dimension**	**Screen with 1st. 20% Retained**	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	0.02							
R	**Residual AC Cont**		0.665								

-100 ADT on Badly Pocked & oxidized

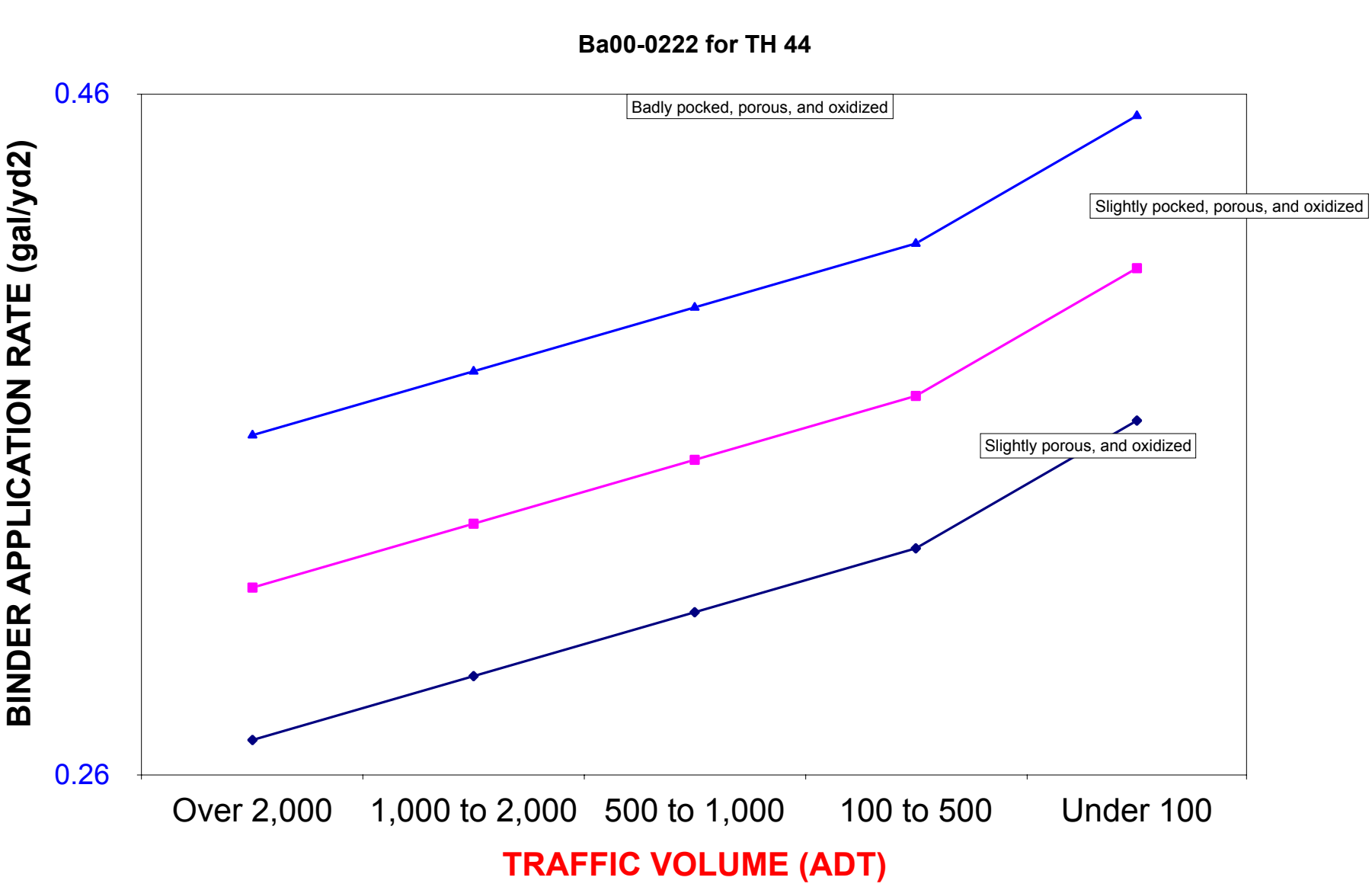
Binder Appl Rate =	0.587	Gal/yd2	2.244	0.294	0.85	0.5	0.09	0.02			
					0.665						

-100 ADT on Slightly pocked, Porous & oxidized

Binder Appl Rate =	0.542	Gal/yd2	2.244	0.294	0.85	0.5	0.06	0.02			
					0.665						

-100 ADT on Slightly Porous & oxidized

Binder Appl Rate =	0.497	Gal/yd2	2.244	0.294	0.85	0.5	0.03	0.02			
					0.665						


Ba00-0222 for TH 44
0.46
0.26
BINDER APPLICATION RATE (gal/yd2)
Badly pocked, porous, and oxidized
Slightly pocked, porous, and oxidized
Slightly porous, and oxidized
Over 2,000
1,000 to 2,000
500 to 1,000
100 to 500
Under 100
TRAFFIC VOLUME (ADT)

Aggregates

Standard Chipseal Aggregate Requirements

- Must be clean - For reliability
  - Less then 1-2% 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.
- Need to have fractured faces for stability

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 +1.1 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

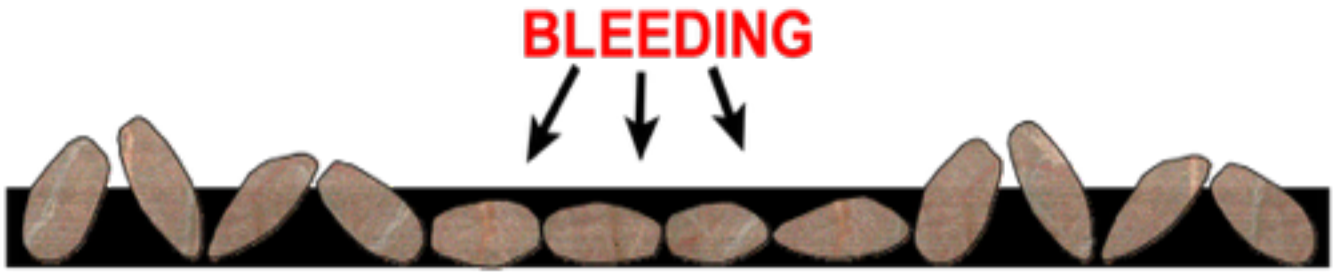
- Single sized Chips
  - More uniformed height
  - Has more room for binder – Space not filled by smaller aggregate particles.
  - The more single sized the easier it is to develop a good chipseal design.

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.

Binders

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	
Test on the Residue From Distillation			
Penetration @77°F	T 49	100	250
Torsional Recovery %	See Note[2]	18	
or			
Toughness/Tenacity in-lbs	See Note[3]	50/25	

[1]Distillation modified to use 300 grams of emulsified asphalt heated to 350°F ± 9°F and maintained for 20 minutes.

[2]The Torsional Recovery test shall be conducted according to the California Department of Transportation Test Method No. 332. The residue material for this test shall come from California Department of Transportation Test Method No. 331.

[3]Benson method of toughness and tenacity; Scott tester, inch-pounds at 77°F, 20 inches per minute pull. Tension head ¾-inch diameter.

Specification Change to CRS-2P

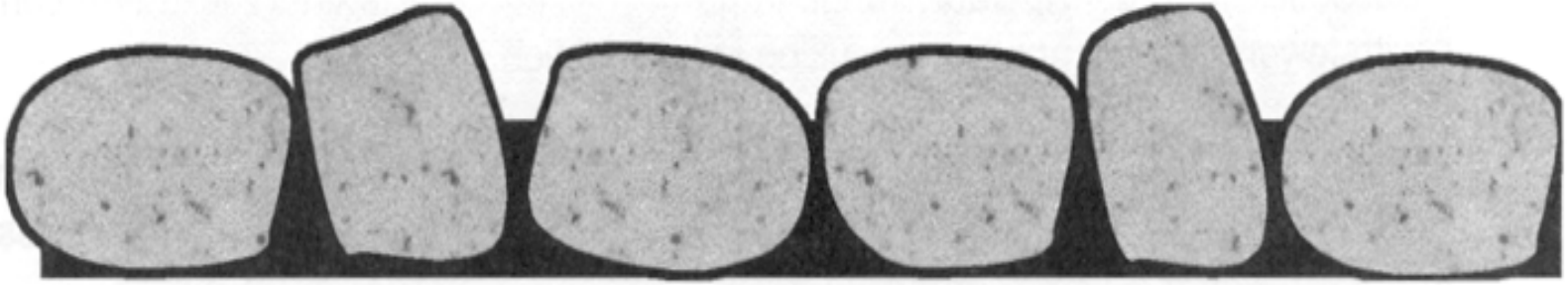
- Beginning with 2015 specification change to the CRS-2P specification
- AASHTO T 301 Elastic Recovery Test - 50% min will replace:
- Torsional Recovery - 18% min

  And the alternate
- Toughness and Tenacity test - 50/25 min.

CMS-2P

- There is no WSDOT specification for this material.
- Generally very close to CRS-2P specifications but with the addition of a distillate to slow the break slightly.
- Most suppliers will offer the specification they are producing to.

Standard Chipseal



- One layer thick
- Asphalt Residue glues the chips down
  - It's the main source of strength for the seal
- CRS-2P needs clean chip to adhere to due to fast break
  - Major cause of seal failure is dirty chip
- Need enough Glue to hold the chip
  - Major cause of seal failure is not enough glue.
- Need enough compaction before winter
  - Major cause of seal failure is low compaction / rock is sitting up high

There is more to a successful Design than the numbers

- Timing:
  - **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

Holes left by late water vapor escaping the seal

There is more to a successful Design than the numbers

- 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%
- If you don't have enough traffic, the voids won't decrease and the binder will not reach the design level. Possible seal failure until final embedment / voids are reached.

Need more rolling

- While the wheel paths get the compaction needed for a successful McLeod designed 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

38,000 lb. Vibratory
Bonner County, Idaho

Note the Effect on the Aggregate Texture

½ In. Chipseal

Maintenance Seal
High Float Emulsion and Crushed Cover Stone

- Use HF-150 and Crushed Cover Stone vs. ½ to ¼ and CRS-2P
- Application rate is .40 to .46 gal/yd^2 vs. .55+ gal/yd^2 for CRS-2P.
- This technology similar to that used in Scandinavian Countries “Otta” Seal
- Highly reliable seals
- TRB report No. 1989 Discusses “Otta” seal

Maintenance / Otta Seal

- Matrix of rock like hotmix
  - Rocks interlock for strength
    - The more fracture the better
  - Asphalt Residue fills small voids and surrounds rocks like in hotmix
  - Strength comes from interlock & glue
    - Twice the forces , Adds to reliability

High Floats Emulsions
Ex: HF-150

- Slower setting than CRS-2P, CMS-2P
- Chemistry reduces temperature and bleeding susceptibility
- Very versatile, can be used with very dirty aggregate or slow application processes
- Soft residue allows traffic to knead the seal for a longer time adding to embedment
- Lower cost than Polymer emulsions

Asphalt Emulsion HFE-150 Specifications

Test on Emulsion		**Minimum**	**Maximum**
- Viscosity @ 122 Degree F SFS	T59	50	400
- Sieve test %,	T59	--	0.3
Distillation:			
- Oil Distillate by volume of emulsion %	T59	--	5
- Residue %	T59	65	--
Tests on the Residue from Distillation:			
- Penetration 77 Degrees F, 100g, 5s	T49	150	300
- Float at 140 Degrees F., sec.,		1200	--

WSDOT “crushed Cover Stone” 9-03.4(2)

• ¾” square	100 % passing
• 5/8” square	95-100
• U.S. No. 4	20-45
• U.S. No. 200	0-7.5
• % fracture by wt., min.	75
• Sand Equivalent min.	40
• Static Stripping test	Pass

- Much dirtier than chips used with cationic emulsions
- **Much lower cost material as we keep many of the agg. Sizes vs. screening them off as waste during chip production.**

Adams County Aggregate Spec

Coverstone Maintenance shall meet all the requirements of Section 9 -03.4(2) except that it shall meet the following specifications for grading, fracture and sand equivalent:

Sieve Size	Percent Passing	Tolerance Limits
3/4" square	100	95-100
5/8" square	95-100	90-100
US No. 4	20-45	16-49
US No. 200	**0-5.0**	0-6.5
% fracture, by weight, min	90	85
Sand equivalent min.	40	35

The third paragraph of Section 9-03.4(2) is revised to read:

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


WSDOT Crushed Cover Stone

Benefits of HF / Maintenance Seals

- Lower EM use, lower rock cost = Substantial Savings $$
- More forgiving during construction
  - Slower to break, more time to work
  - Handles dirtier rock
  - Very low seal failure rate, always something left
- More flexible due to softer residue
  - Retard crack reflection?

Freshly broomed and washed Maintenance seal

Maintenance Seal

Tips for Successful Maintenance Seals

- Maintenance Seals create a matrix much like hotmix
  - Treat them like hotmix
  - Higher traffic designs need to be compacted more
- Need to increase compaction while the emulsion is still wet and can grab loose rock.
  - Increased rolling effort means more compaction early, grabs rock before it can slough off.
    - Increases thickness of seal (holding more rock) at equivalent emulsion rate.

Tips for Successful Maintenance Seals

- Water can be sprayed over the seal surface while rolling to help emulsion travel through the aggregate and expand coated surfaces.

- Higher traffic = more compaction, less room for asphalt residue. (Just like Hotmix)
  - If you don't compact enough during construction traffic will post compact and flush the surface just like under compacted hotmix.

FA-2 Aggregate Seal
City of Spokane

- Fine graded Seal using #4 Agg, CRS-2P and a post fog
- Provides fine surface for pedestrians and local traffic
- Seems tough – 3rd yr seals holding up very well
- Aesthetically very appealing
- Improves older surfaces much like slurry

SECTION 5-02 BITUMINOUS SURFACE TREATMENT

5-02.2 Materials
(******)

Add the following to the second paragraph:

Aggregate

The aggregate shall meet **FA-2** requirements per the following gradation table:

Table 1 (Values are the percent passing the Sieve).

Sieve Size	FA-1	FA-2	FA-2 1/2	FA-3	FA-4	QC range
12.5 mm [1/2 inch]	100	100	100	100	100	
9.5 mm [3/8 inch]	100	100	100	90-100	0-60	±5%
6.3 mm [1/4 inch]	100	100	0-80	0-70	0-15	±7%
4.75 mm [# 4]	0-100	0-100	0-50	0-25	0-5	±7%
2.36 mm [# 8]	—	0-40	0-12	0-5	—	±4%
1.18 mm [# 16]	0-30	0-10	0-5	—	—	±4%
300 µm [# 50]	0-15	0-5	—	—	—	±4%
150 µm [# 100]	0-5	—	—	—	—	±4%
75 µm [# 200]	0.0-1.0	0.0-1.0	0.0-1.0	0.0-1.0	0.0-1.0	
Material Tests						
% Shale, max. Mn/DOT 1209	5	5	5	3	2	
Flakiness Index, max. %, FHL T 508 [1]	N/A	25	25	25	25	
Los Angeles Rattler, max. % loss, AASHTO T 96 (Mn/DOT) Modified			37	37		

[1] Aggregate retained on each sieve, which comprises at least 4 percent of the total sample shall be tested.

Chips shall be washed after manufacture by a method approved by the Engineer.

FA-2 Chip Seal Specs

- CRS-2P .15 to .25 G / SY
  - Application at the higher end holds multi layers of rock for finer surface more surface correction
- FA-2 Rock 15 to 25 lbs / SY
  - Will sweep off a good percentage but need to place initially to absorb / account for all the CRS-2P
- Rapid Curing Fog Emulsion .1 to .15 G / SY
  - Extra Insurance and gives a final appearance like pavement


LIBERTY
IN GOD WE TRUST
1998

Issues with FA-2 Seals

- Finer seals show deformities more than larger seals
  - Need to not leave large bands of crackfiller they transfer through
  - Drilling of the seal can be an issue with thicker emulsions, smaller rock and this high emulsion rate will show this more

Points to remember

- Do a design / Understand the size and cleanliness of your rock, the condition of the road and traffic count.
- Do your sealing early in the season (You need cure time)
  - Need time to get rid of the last water
  - Need time to get the rock compacted to its most stable dimension
- Add that steel roller and roll, roll, roll,
- If good chip is hard to find, if you can't get the precision you need for McLeod,
  - Try a Maintenance Seal