Chip Seal (Seal & Cover) Applications in Montana

Western Canada Pavement workshop edmonton alberta - February 2018

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Facts about Montana

- Population ~ 1,000,000
- Construction Budget: ~ $ 400,000,000 USD
- Cattle ~ 2,500,000
- Binder PG: 70-28, 64-28, 64-22
- 99% Flexible Pavement
- Interstate System: 2,402 mi (3,867 km) centerline miles
- National Highway/Primary: 5,653 mi (9,101 km) centerline miles
- Secondary: 2,937 mi (4,722 km) centerline miles
- Total 10,992 mi (17,697 km) centerline miles
Seal & Cover (includes new construction)

- $1 USD = 1.23 CD
- 1 SY = 0.836 SM
- Cost ~ $3/SY (C$3/m^2)
  - Chips $0.50/SY
  - Seal $1.00/SY

- 205,000,000 SY (171,380,000 m^2) of paved roads
- Chip seal ~ 6% of our network annually (10% ideal)
Pavement preservation cycle

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reconstruct / Chip seal</td>
<td>0</td>
</tr>
<tr>
<td>Chip seal</td>
<td>7</td>
</tr>
<tr>
<td>Overlay / Chip seal</td>
<td>14</td>
</tr>
<tr>
<td>Chip seal</td>
<td>21</td>
</tr>
<tr>
<td>Mill / Fill / Chip seal</td>
<td>28</td>
</tr>
<tr>
<td>Chip seal</td>
<td>35</td>
</tr>
<tr>
<td>Major rehab / Chip seal</td>
<td>42</td>
</tr>
</tbody>
</table>

20 year Pavement design
Surface Type | Skid #
---|---
Chip Seal: | 55-75
Microsurfacing: | 55-75
Plant Mix: | 45-75
Concrete: | 30-40

**Highly source specific (hardness, gradation, etc.)

<table>
<thead>
<tr>
<th>Skid Number</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 30</td>
<td>Take measures to correct</td>
</tr>
<tr>
<td>≥ 30</td>
<td>Acceptable for low volume roads</td>
</tr>
<tr>
<td>31 - 34</td>
<td>Monitor pavement frequently</td>
</tr>
<tr>
<td>≥ 35</td>
<td>Acceptable for heavily traveled roads</td>
</tr>
</tbody>
</table>
**Mechanistic Empirical Design Calibration**

### Performance Comparisons: Montana Vs. Adjacent States

<table>
<thead>
<tr>
<th>Distress, Average</th>
<th>Montana Sections</th>
<th>Adjacent State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rutting, in.</td>
<td>0.29</td>
<td>0.50</td>
</tr>
<tr>
<td>Transverse Cracking, ft./mi.</td>
<td>479</td>
<td>2026</td>
</tr>
<tr>
<td>Semi-Rigid; Fatigue Cracking</td>
<td>None</td>
<td>55%</td>
</tr>
<tr>
<td>Longitudinal Cracking, ft./mi.</td>
<td>965</td>
<td>1576</td>
</tr>
<tr>
<td>Raveling</td>
<td>None</td>
<td>30%</td>
</tr>
</tbody>
</table>

Result: Systematic difference in performance between Montana sections & those in adjacent States
Recent Statewide Centerline Rumble Strip Project

- Fog seal applied over rumble strips
- Chip seals will be nominated for each of these roads
  - Low density at longitudinal joint
So how did it all start??

1930's - First Specification

OIL TREATED CRUSHED ROCK OR CRUSHED GRAVEL SURFACE COURSE.

SECTION 23.

ROAD MIX TREATMENT.

23.1 Description. The road mix oil treated surface course shall consist of a mixture of crushed rock or crushed gravel and asphaltic road oil prepared on the roadbed by mechanically mixing the oil and surface material and spreading and compacting the mixture to the width, thickness, and typical cross section shown on the plans.

23.6 Seal Coat. After the surface has been opened to traffic for a period of three weeks or more, should the Engineer consider it necessary to seal the surface, a seal coat consisting of the specified type and grade of bituminous material shall be applied. Before applying the seal coat the surface shall be swept free and clean so that no vegetable matter, paper, dust, or other obstructions might prevent a complete coverage or bond. The bituminous material shall be heated to a temperature within the limits specified in Article 23.2 (b) and shall then be spread at the rate of approximately one-eighth of a gallon per square yard of surface covered by means of a pressure distributor of approved type.

Traffic shall be routed over detours while the seal coat is being applied or the seal coat shall be placed one-half width of the road at a time and the other half of the road to traffic.

The state reserves the right to omit the seal coat if in the opinion of the Engineer.
1936 Billings Broadview Road
1939 KALISPELL - LIBBY HIGHWAY

TYPICAL SECTION

FILL SLOPES
Use 4:1 slope for fill of 5’ or less.
Use 1:1 slope for fill over 5’ and widen crown 10’ each side as shown use additional widening & carry profile grade on curves as per standard.

As req’d for borrow drain agle up to 20’ max. Any add width req’d to be on 6.0.

CUT SLOPES
Excavation is prohibited below slope line as shown.

QUANTITIES

STONE CHIPS
GRADE "A"
AREA SQ. FT.
Cu Yds per Sta.
Cu Yds per Sta.

Gravel
TOP COURSE
10.417
33.881
2037.0

Sub Base

50.635
176.553
4033.9

Oil
MIX
Sq. Yds Per Sta.
222.222
203.030

Seal 95+ Gals. Per Sta.
222.222
74.074

*Add 20% for Subbase compaction.
1940 'Std. Spec. for Road and Bridge Construction'

**SECTION 26**

**SEAL COAT OILING**

(With Stone Chips)

26.1 **DESCRIPTION.** This item shall consist of applying specified grade, type, and amount of bituminous material to the completed surface, and spreading and rolling stone chips thereon.

26.2 **MATERIALS.** The bituminous material shall be of the grade and type as specified on the plans or in the proposal form or special provisions and shall conform to the specifications as set forth under Section 21 or Section 25.

The stone chips shall meet the requirements as set forth for "Stone Chips" under Section 23-A.

26.3 **CONSTRUCTION METHODS.** All vegetable matter, paper, dust, or other obstructions which might prevent a complete coverage or bond between the bituminous material and the roadway shall be swept or cleaned from the roadway surface with an approved type power broom, or by hand sweeping, or both, as required. Following the cleaning of the roadway the bituminous seal coat material of the grade and type specified shall be applied to the amount designated by the Engineer. Application shall be by means of a pressure distributor of the type specified under "Bituminous Surface Coats, Road Mixes," Section 24. No bituminous material shall be applied when the roadway surface is damp or wet.

Immediately following the application of the bituminous material, the stone chips shall be spread evenly over the treated surface in the amount desired to be applied by means of a spreader. After the chips have been spread and leveled, the surface shall be rolled with a weighing, not less than six, three-ton roller, until the surface is smooth and uniform.

26.4 **PROTECTION AGAINST TRAFFIC.** All new roadways or any other roadways from being damaged by vehicles, workmen, or equipment, the roadway shall be protected from traffic for a distance not less than 300 feet from the point where the work is being done.

When the roadway is to be applied to more than one lane at a time, and if directed as only one third of the work is to be performed, the remaining lanes shall be kept clear and open for traffic.

In addition to the provision of Sections 21.2 and 7.6, the work shall be protected from traffic for a distance not less than 100 feet.

26.5 **METHOD OF MEASUREMENT.** The asphaltic road oil shall be measured, by the linear yard of 50 feet, or as specified in the next paragraph. This work shall be measured by the quantity of the material placed in the work.

(1) The asphaltic road oil shall be measured by the length of the roadway in feet, or as specified in the next paragraph.

(2) Applications of oil in square feet, the measurement in square feet.

**SECTION 23-A**

**STONE CHIPS**

23-A1 **DESCRIPTION.** This item shall consist of one or more courses of crushed and screened gravel or stone, placed on the roadway in accordance with these specifications and in conformity with the plans, grades, and thickness shown on the plans or designated by the Engineer.

23-A2 **MATERIAL.** The material for this work shall be crushed from rock or gravel having a loss of not exceed 40% when subjected to 500 revolutions of the Los Angeles abrasion machine and shall be uniform in quality and grading. When tested by means of laboratory sieves it shall meet the following requirements:

- Passing 3/8 inch square sieve: 100%
- Passing 4 mesh square sieve: 15%
- Retained on 10 mesh sieve: 95%

75% of the aggregate particles between the 3/8 inch sieve and 4 mesh sieve shall show at least one fractured face.

23-A3 **METHODS OF MEASUREMENT.** Stone chips shall be measured by the ton of 2,000 pounds unless specified otherwise in the proposal form or special provisions.

All requirements as set forth under Section 23-A, Methods of Measurement, shall be complied with in measuring stone chips.

23-A4 **BASIS OF PAYMENT.** Stone chips shall be paid for at the contract bid price per ton or as otherwise designated in the proposal form or special provisions.
SECTION 36
BITUMINOUS SURFACE TREATMENT
Type A

36.01 DESCRIPTION. This item shall consist of a bituminous surface treatment composed of a prime coat, a mat substantially the thickness of the largest aggregate specified and a seal coat. It shall be constructed on a properly prepared base course which may consist of either a naturally stable earth base course, artificially stabilized base course, a macadam base course, a bituminous treated base course or other base or cushion course as required. It shall be constructed in accordance with the lines, grades and typical cross-section as shown on the plans.

SECTION 30
STONE CHIPS

DESCRIPTION. This item shall consist of crushed gravel or other (a) placed in stock piles at designated locations for use, or (b) placed on the roadway in accordance with the method shown on the plans or designated by the Engineer, and in conformity with the methods hereinafter set forth in Section 30.

MATERIAL. The material for this work shall be screenings and stone or crushed gravel. It shall consist of clean, durable fragments free from an excess of flat, elongated, disintegrated pieces, clay balls or other objectionable material. Chips as produced shall have a crisp, clean appearance and be free from adherent films of clay or rock dust and shall be washed thoroughly unless otherwise provided in the special provisions. They shall have a per cent of wear not more than 1.0 at 500 revolutions as determined by A.A.S.H.O. Method T-96 (Los Angeles Abrader Test). The abrasion test shall be run using a 5,000 gram sample charge of material between the three-eighths inch and No. 4 sieve and an abrasive charge of 8 balls.

Stone chips shall consist of the product obtained by crushing and screening material that has first been screened in such a manner that not less than 95 percent of the material for crushing, when tested by laboratory methods, is retained on a screen having openings one inch square, unless otherwise specified in the special provisions.

When tested by laboratory screens in conjunction with a water wash, chips shall meet one of the following gradation requirements as specified in the proposal form or special provisions.

<table>
<thead>
<tr>
<th>Sieve designation</th>
<th>Percentage by weight passing square mesh sieve (A.A.S.H.O. T-27)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grading A</td>
</tr>
<tr>
<td>1/2 Inch</td>
<td>100%</td>
</tr>
<tr>
<td>3/8 Inch</td>
<td>100%</td>
</tr>
<tr>
<td>No. 4</td>
<td>0-20%</td>
</tr>
<tr>
<td>No. 10</td>
<td>0-2%</td>
</tr>
<tr>
<td>No. 100</td>
<td>0-2%</td>
</tr>
</tbody>
</table>
New Construction - Minimum Typical Section

Seal & cover

90mm of (19 mm) Grade-S HMA

200mm of (38 mm) Gravel
New Construction - Typical Section

- **Cover Type 1, 2 or 3** - 25 #/SY (13.57 kg/m²)
  - **LA Wear** - 30% Max
  - **1 Face Fracture** 70%
  - **HMA Wear** - 40% Max

- **CRS-2P Application** - 0.4-0.5 GAL/SY (1.81-2.26 L/m²)
Fog Seals

Benefits:
- Black surface can aid in curing the chip seal
- Eliminate fly rock
- Improves contrast with striping
- Added protection for the first season

Lessons Learned:
- 0.15 gal / sy (0.68 L / m²) Minimum Application Rate
- Let traffic on the chip seal to seat the chips prior to the fog seal
- Fog seals can render the warranty useless and allow a marginal chip seal to make it through the warranty period
Research: 2011 - Beavertail Road - Fog seal over millings
2015 Fog Seal over Chip Seals

Lincoln East          Marias Pass
Research: 2015 - Taft West - Fog Seal over Chip Seal

- Purpose: quantify benefits of fog seals
- Conditions too extreme to make fog seal beneficial for long term performance

Chip only

W/ fog seal

*Experimental layout for fog seal/seed & cover project: Taft West/IM 90-11(245)*

- Westbound 90
- Eastbound 90
- Lookout Pass
- Taft

Conventional Chip Seal
Fog Seal over Chip Seal
Conventional Chip Seal
Fog Seal over Chip Seal

- Added FSCS due to additional emulsion onsite

Montana Department of Transportation

Vision Zero
Zero deaths - zero serious injuries
Scrub Seals

- Integrated crack seal and chip seal process
- Polymer Modified Rejuvenating Emulsion (PMRE)
- 4 pilot projects in maint. and const. Programs
- Roads are often in need of heavier treatments
- Likely candidates: urban streets, secondary hwy's
CHFRS-2P

- POLYMER MODIFIED CATIONIC HIGH FLOAT RAPID SET
- CHIPS STICK BETTER, RETURN TO TRAFFIC SOONER - LESS ‘FLY’ ROCK
- GEL STRUCTURE LESS BRITTLE, LESS BLEEDING/FLUSHING
- COST IS 5-10% HIGHER THAN CRS-2P
- USED ON NUMEROUS CHIP SEALS BY OUR MAINTENANCE DIVISION

OVERWHELMING POSITIVE FEEDBACK

-TWO PROJECTS SLATED TO COMPARE CRS-2P W/ CHFRS-2P
Micromill & Chip Seal

- Removed Open Graded Friction Course (OGFC)
- CHFRS-2P
- Type III chips (½”)
- Low speed, so noise/ride not an issue
- From past pilot projects, ride quality
- Cost: $4/SY (~C$4 /m²)
**Texas Underseal**

- Better seal pavement from moisture
- Flexible membrane for reflective crack mitigation?
- Rejuvenate stripped plant mix??
- Three projects slated to evaluate the treatment

**Seal & Cover**
- 3/4" grade-S HMA
- Seal & cover
- Existing chip seal
- Or milled HMA

**No Upper Seal & Cover**
- 3/8" grade-S HMA
- Seal & cover
- Existing chip seal
- Or milled HMA

Issues to discuss:
- Running traffic on milled surface
- Timing before paving
Cape Seal

- Microsurfacing over chip seal
- Intermediate priced treatment between chip seal or microsurfacing and a HMA overlay
- Ability to address rutting
- Quieter ride of microsurfacing, better moisture barrier of a chip seal
- First Cape Seal slated for 2020
- Cost $6.00/SY (C$6.00/M^2)
Inverted Cape Seal

- Chip seal over microsurfacing
- Intermediate priced treatment between chip seal or microsurfacing and HMA overlay
- Ability to address rutting
- Better moisture barrier of a chip seal over microsurfacing
  (Reflective cracks occur the year after microsurfacing)
- Two constructed in 2017
- Cost $6.00/SY (C$6.00/M²)
Chip Seal Problems

- Short construction season (most chipping occurs between July 4 and August 2)
- Warranty (too short?)
- Bleeding / Flushing
- Lack of embedment!!
  ~70% recommended (after break)
- Emulsions are 1/3 water
- Bad emulsion
- Over oiled ½” chip seal may cause rutting in the plant mix
Unsealed Pavement first Winter / Spring

Low plant mix density / segregation

Causes Increase in base / subgrade moisture:

- Lowers strength
- Increases pavement deflection / fatigue

A chip seal the first season makes a big difference on some roads, especially with marginal plant mix

- Dutton East
- Standford North
- Lincoln East
 QUESTIONS.......???

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Some Good References:

- NCHRP Report 680
- NCHRP Synthesis 342
- Minnesota Chip Seal Handbook (2006-34)
- MDT Chip Seal Manual