

Chip Seal Quality Construction

State-of-the-Practice

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TECH BRIEF

This document is a brief technical summary on chip seal preservation treatments which is included in a larger report, ***State-of-the-Practice in Chip Seal, Slurry Seal, Micro Surfacing and Thin Lift Asphalt Overlay Construction Quality Assurance*** (Report No. 715-15-050). This Tech Brief provides information on chip seal specifications and construction practices. It then summarizes state-of-the-practice elements that could lead to quality construction.

Introduction

A chip seal “consists of a uniform spray application of an asphalt binder followed by a uniform application of a graded cover coat aggregate which is then rolled with pneumatic tire rollers over a properly prepared surface.”⁽¹⁾ This Tech Brief summarizes the specifications and construction state-of-the-practice for four agencies: California Department of Transportation (Caltrans), Minnesota Department of Transportation (MnDOT), Spokane County Public Works in Washington state and Texas Department of Transportation (TxDOT). The agencies were selected based on agency experience, construction volume, and reported performance. All of these elements were determined using surveys and interviews. The standard chip seal specifications for these agencies are summarized and compared.⁽²⁻⁵⁾ Spokane County self-performs chip seals, unlike the three other agencies. Additionally, two case studies are presented.

Chip Seal Pre-Construction Considerations

The actual pre-construction considerations are beyond the scope of this study. However, these considerations are the first step in achieving a well-performing chip seal treatment. They include project selection based on pavement condition, pavement age, traffic, and climate. Such considerations should be used in a decision matrix or decision tree to determine which preservation treatment is the appropriate treatment to use on a particular pavement.

Chip Seal Specifications

Caltrans, MnDOT, Spokane County and TxDOT appear to have effective specifications and manuals for chip seal treatments. The chip seal specification summary for the four agencies is presented in Table 1.

Materials.

All four agencies specify a CRS-2P asphalt emulsion. For MnDOT and Spokane County, this is the only emulsion used. Caltrans and TxDOT specify a wide variety of emulsions and asphalt binders in addition to CRS-2P. Some of the emulsions specified by Caltrans include polymer-modified anionic and cationic grades PMRS-2, PMRS-2h, PMCRS-2, and PMCRS-2h. Caltrans also specifies either unmodified paving grade asphalt or Crumb Rubber Modified (CRM) asphalt binder (henceforth referred to as asphalt rubber binder) for hot-applied chip seals. TxDOT specifies AC-5, AC-10, AC-5 with 2% polymer, AC-15P, AC-15-5TR and Asphalt Rubber (AR) types AR-II and AR-III binders. Emulsions specified include HFRS-2, MS-2, CRS-2, CRS-2h, HFRS-2P and CRS-2P. For cool weather conditions, TxDOT specifications include emulsion and cutback grades: RS-1P, CRS-1P, RC-250, RC-800, RC-3000, MC-250, MC-800, MC-3000 and MC-2400L.

Caltrans specifies different aggregate gradations based on chip seal type. For emulsion chip seals, the coarse, medium, medium-fine, and fine gradations have Maximum Aggregate Sizes (MAS) of 3/4 inch, 1/2 inch, 3/8 inch, and 3/8 inch, respectively. Pre-coated aggregate is required for hot-

applied chip seals. The MAS for the coarse, medium, and fine gradations for hot-applied chip seals is 3/4 inch.

MnDOT specifies five gradations: FA-1, FA-2, FA-2½, FA-3 and FA-3½. The MAS is ¼ inch for FA-1 and FA-2, 3/8 inch for FA-2½ and FA-3, and ½ inch for FA-3½. Spokane County uses only single-size aggregate chips. The sizes are 5/8 inch by No. 4, 1/2 inch by No. 4, and 3/8 inch by No. 4.

TxDOT specifies either graded or single-size aggregate gradations with gradation types 1, 2, 3S, 3, 4S, 4, 5S and 5. The S denotes a single-size gradation. The MAS is 7/8 inch for Grade 1 and Grade 2, 3/4 inch for Grades 3 and 3S, 5/8 inch for Grade 4 and 4S, and 1/2 inch for Grade 5 and 5S, respectively. Pre-coated aggregate may also be used. Grades 3, 4 and 5 are the most commonly specified aggregate gradation in Texas.

Mix Design and Verification.

Caltrans, MnDOT, and TxDOT require the Contractor to provide a mix design for approval. Spokane County self-performs all chip seals and does the designs in-house. MnDOT, Spokane County and TxDOT all specify a modified version of the McLeod mix design method. However, TxDOT also specifies a modified Kearby method, which is more commonly used. MnDOT's modification allows for 70% chip embedment depth to mitigate snowplow damage. In addition to common mix verification practices, Caltrans testing includes the Vialit test, which measures chip retention as a function of target asphalt content.⁽⁶⁾

Table 1. Chip Seal Specifications Summary.

<i>Elements of Specifications^a</i>	Caltrans	MnDOT	Spokane County	TxDOT
Asphalt Binders	PG Binder—Unmodified/Modified. Emulsions—Unmodified/Modified.	Emulsions—CRS-2P only. No latex.	Emulsions—CRS-2P only.	PG Binder—Unmodified/Modified. Emulsions—Unmodified/Modified. Cutbacks.
Aggregates	Crushed stone and/or gravel. Pre-coated aggregate (hot-applied chip seal).	Crushed stone and/or gravel.	Basalt.	Slag and/or limestone. Pre-coated aggregate (hot-applied chip seal).
Mix Design/ Verification	Verification tests included.	McLeod—including modifications. Verification tests included.	McLeod—including modifications.	Kearby—including modifications. Verification tests included.
Equipment and Calibration	Either equipment or calibration details.	Either equipment or calibration details.	Either equipment or calibration details.	Both equipment and calibration details.
Calendar Date/Climate Limits	Temperatures only—ambient and/or surface. Calendar dates and/or temperatures vary with binder type.	Calendar dates and temperature limits.	Calendar dates and temperature limits.	Calendar dates and temperature limits. Calendar dates and/or temperatures vary with binder type.
Inspection	Monitor binder temperatures. Inspection of application rates. Monitor rolling pattern.	Monitor binder temperatures. Inspection of application rates. Monitor rolling pattern. Test strip constructed.	Agency inspection only. Monitor binder temperatures. Monitor rolling pattern. Test strip constructed.	Monitor binder temperatures. Inspection of application rates. Monitor rolling pattern. Test strip constructed.
Opening to Traffic	Opening to Traffic > 2 hrs.	Not specified.	Not specified.	Not specified.
Quality Control	QC includes materials testing.	QC includes materials testing.	QC includes materials testing.	QC includes materials testing.
Acceptance	Acceptance includes materials testing.	Acceptance includes materials testing.	Acceptance includes QC materials testing.	Acceptance includes materials testing.

^aInformation obtained from standard specifications, published documents, and phone interviews.

Climate and Surface Preparation.

Caltrans specifies different surface and air temperature ranges based upon binder type. For unmodified emulsion chip seals, pavement surface temperature must be at least 80°F and air temperature must be between 65-110°F. For polymer-modified emulsion chip seals, surface temperature must be at least 80°F and air temperature must be between 60-105°F. For asphalt rubber binder chip seals, surface

temperature must be at least 55°F and air temperature must be 60-105°F.

MnDOT specifies that the minimum surface and air temperatures must be at least 60°F and rising. Calendar dates to begin and end construction are specified and are based upon project location. The construction season in the North and North Central Zone is May 15 to August 10. South of these zones, the season is May 15 to August 31.

Spokane County specifies that minimum surface temperature be at least 55°F and air temperature 60°F and rising. The maximum allowable surface temperature is 130°F. The construction season is May 1 to August 31.

TxDOT specifies that minimum surface and air temperatures be at least 70°F when using polymer-modified asphalt and asphalt rubber binders. The minimum surface temperature for all other chip seals is 60°F with a minimum air temperature of 50°F. Typical calendar date limits are from June to September, per TxDOT's *Seal Coat Manual*.⁽⁷⁾

Surface preparation includes cleaning the surface of all deleterious material and covering exposed roadway structures. Proper surface preparation ensures bonding between the treatment and existing pavement. It is common for the agencies to do preparatory work prior to chip seal application such as crack sealing/filling and localized pavement patching.

In addition to these requirements, MnDOT and TxDOT recommend applying a tack coat prior to construction of the chip seal treatment. MnDOT's tack coat consists of a 1:1 diluted CSS-1h emulsion applied at a rate of 0.05-0.10 gal/yd². Though not commonly used, TxDOT's tack coat consists of a SS-1h or CSS-1h emulsion or a PG of 58 or higher.

Equipment.

All agencies specify equipment requirements for asphalt distributors, haul trucks, chip spreaders, rollers, sweepers, and auxiliary equipment. All of the agencies also specify pneumatic

tire roller compaction. Spokane County requires steel-wheel rollers for finish rolling. This is possible without damaging the single-size chips because the basalt aggregate used is very tough. Caltrans also specifies steel-wheel rollers in some cases if the LA Abrasion Resistance (LAR) of the aggregate is less than 25.

The recommended industry standard is to calibrate equipment prior to the construction of every project. MnDOT's *Seal Coat Handbook* recommends calibration of the distributor and chip spreader prior to every project.⁽⁸⁾ Spokane County specifies annual self-performed calibration. This is done by Spokane County as the county owns its chip seal equipment. TxDOT specifies that equipment is to be calibrated prior to the construction of each project. The *TxDOT Seal Coat and Surface Treatment Manual*, as well as the International Slurry Surfacing Association (ISSA) A165— *Performance Guideline for Chip Seal* include equipment calibration procedures.^(1,7)

Inspection.

Table 2 shows some of the primary inspection practices that are used by the agencies. All four agencies specify monitoring the binder temperature and materials application rates during construction. Provisions for application rate adjustments are common in chip seal specifications to allow for changes in pavement surface conditions.

Caltrans specifies that for asphalt rubber binder chip seals, the binder must be heated to 375-415°F. Caltrans does not specify temperatures for emulsion chip seals. MnDOT specifies that CRS-2P emulsion be heated to 140°F. Spokane

Table 2. Construction Inspection requirements.

Inspection Item	Caltrans	MnDOT	Spokane County	TxDOT
Calibration	Not specified; may require the Contractors to follow the equipment manufacturers' recommended calibration procedures.	Not specified in specifications; specified in <i>Seal Coat Handbook</i> for distributor and chip spreader.	Not specified in specifications, but County owns equipment, so self-calibrates frequently.	Required prior to treatment construction.
Test Strip Requirements	Not specified.	200-ft long to check application rates.	1,000-ft long and checks equipment calibration, emulsion temperature, and rolling pattern.	Required if mix adjustments made.
Asphalt Binder Temperature	For asphalt rubber binder, must be between 375-415°F.	Heated to 140°F.	Heated to 125-195°F.	Must be maintained within $\pm 15^\circ\text{F}$ of the target, but not above the maximum temperature.
Binder Application Rate	Not specified.	Not specified.	Not specified.	Must not vary by more than 0.03 gal/yd ² on three consecutive shot lengths or by more than 0.05 gal/yd ² on any shot length.
Aggregate Application Rate	Must be within 10% of target rate.	Must be within ± 1 lb/yd ² of target rate.	Not specified.	Must not be more than ± 1 lb/yd ² off of the target rate.
Compaction	Pneumatic-tire rollers. Three coverages: one initial coverage and two final coverage passes.	Pneumatic-tire rollers. Three complete coverages.	Pneumatic-tire rollers. Two complete coverages.	Pneumatic-tire rollers. Five complete coverages.
Fog Seal/Flush Coat	Flush coat applied on asphalt rubber binder chip seals (emulsion and sand)	Consists of 1:1 diluted CSS-1h emulsion.	Not specified.	Not specified.

County specifies that CRS-2P emulsion must be between 125-195°F. TxDOT specifies temperature ranges that are binder-specific.

Caltrans specifies that the aggregate application rate must be within 10% of the target rate. The aggregate must be spread within two minutes of applying the binder. Rolling must commence within 90 seconds of the aggregate application and begins with one coverage of a pneumatic-tire roller for initial rolling, followed by two coverages for final rolling. Sweeping begins after

rolling to remove excess aggregate. During the sweeping process, traffic is controlled (guided via signage and/or pilot cars for two lane roads). Final sweeping must be completed before opening to uncontrolled traffic. Caltrans specifies that, for asphalt rubber binder chip seals, the binder application rate may be reduced by 0.05 gal/yd² in the wheel paths.

MnDOT specifies that the aggregate is to be spread within one minute of applying emulsion at a rate that is within ± 1 lb/yd² of the target spread rate. Initial

rolling must commence within two minutes of aggregate spreading and must include three complete coverages. Embedment is monitored during this time. If embedment is not adequate, the binder application rate must be adjusted. One day after construction, a 1:1 diluted CSS-1h emulsion fog seal must be applied at 0.05-0.10 gal/yd².

In addition to monitoring binder temperature and application rates, TxDOT specifies the application rates are to be calculated, and the rolling pattern be monitored. Material spread rates are calculated using rock land and shot. The “rock land” is the area of roadway that is covered by one truckload of aggregate and “shot” is the area of roadway covered by one distributor load of binder. The lengths of each must be calculated, ensuring that the shot length is an even multiple of rock land. The binder distributor must contain sufficient material to cover an entire shot length.

Additionally, TxDOT specifies binder temperature to be maintained within $\pm 15^{\circ}\text{F}$ of the target, but not above the maximum temperature allowed for that binder type. The transverse binder application rate must not vary by more than 0.03 gal/yd² on three consecutive shot lengths or by more than 0.05 gal/yd² on any single shot length. The transverse aggregate application rate must be within ± 1 lb of the target. At least five passes must be made with enough rollers to complete one full width with each pass. If non-uniformity occurs during application, adjustments must be made, and the corrections are verified with a test strip before construction can resume.

Test Strip Requirements

The recommended industry standard is to construct test strips prior to construction for every project. Some items that a test strip checks for are:

- Check the materials proportion optimization and that the proportions are kept within job mix formula (JMF) tolerances.
- Verify application rates.
- Check for uniformity of surface texture.
- Ensure that the equipment is in good condition.
- Ensure that the workforce is well trained.
- Check the cure time.
- Evaluate workmanship.
- Ensure proper alignment of the equipment.

Test strips should be conducted under conditions that are representative of those anticipated during construction. It should be placed using the same process and equipment to be used during construction.

MnDOT test strip requirements include minimum length and inspection items during test strip placement. The minimum length is 200 ft and inspects the application rates and aggregate embedment in the wheel paths. The test strip is used to adjust mix design application rates to accommodate actual field conditions. Spokane County test strip requirements include minimum length and inspection items during placement. The minimum length is 1,000 ft and inspects the emulsion temperature and rolling pattern. The test strip also verifies proper application rates and equipment calibration. TxDOT specifies that test strips are

required if any adjustments are made to the mix design or application rates, to verify that adjusted application rates are appropriate for the current conditions.

Opening to Traffic and Post-Construction Monitoring.

Caltrans specifies that on two-lane, two-way roads, the treatment may be opened to controlled traffic two to four hours post-construction. On multi-lane highways, the treatment may be opened to controlled traffic (via pilot cars and/or signing) after two hours post-sweeping. The Contractor is required to maintain and sweep the roadway for four days post-treatment, prior to final acceptance.

MnDOT specifies that the treatment may be opened to traffic after the treatment is swept, and a fog seal is applied and cured. The treatment may be opened to traffic after sweeping and prior to fog sealing until a fog seal can be applied. Spokane County specifies that the treatment may be opened to traffic after it is swept and has sufficiently cured.

TxDOT specifies that the opening to traffic time depends upon binder type used, traffic volume, and current climate conditions. The Contractor must maintain the treatment until the Engineer accepts the work.

Quality Assurance.

Caltrans specifies that Quality Control (QC) includes aggregate and asphalt binder testing and checking the asphalt binder application rate. As part of the Caltrans QC process, the Contractor must submit a letter to the Engineer detailing any existing surface defects. MnDOT's QC process includes aggregate gradation and Flakiness Index testing and mix design testing.

The Contractor's emulsion supplier is responsible for performing emulsion QC.

Spokane County's QC process requires the construction crew foreman to monitor production quality and inspect equipment calibration and workmanship. TxDOT's QC includes equipment calibration, temporary storage placement and removal, asphalt rubber blend designs, application rate adjustments and treatment maintenance, in addition to materials testing.

Acceptance.

Caltrans' Acceptance includes testing the aggregate for Gradation and Sand Equivalent. Noncompliant test results warrant a per-ton deduction. MnDOT's Acceptance includes verifying the Contractor's mix design and aggregate QC and verifying the binder application rate. Spokane County's Acceptance includes emulsion acceptance based on a Certificate of Compliance and aggregate acceptance based on gradation test results obtained during annual stockpile production. Recall that Spokane County owns the basalt quarries from which aggregates are obtained. TxDOT's Acceptance includes verifying binder application rate and mix design. Table 3 and Table 4 display the primary QC and Acceptance testing practices specified by all three agencies.

Case Study: Caltrans Chip Seal Project

Caltrans supported a site visit to an asphalt rubber binder chip seal project in July of 2017. The project was located between Post Miles 119-128.7 of US-395 a two-lane rural US highway in Modoc County, California.

Table 3. Contractor Quality Control Sampling & Testing Requirements.

Test Type	Caltrans	MnDOT	TxDOT
Mix Design (Pre-Production)	Not specified.	At least two weeks before beginning construction complete one design per mix and provide information to Engineer.	Not specified.
Production Gradation	Conducted at unspecified frequency.	Stockpile: once per 1,500 tons (at least once per day). Placement: Sampled from Spreader Hopper: once per day.	Conducted at unspecified frequency.
Aggregate Quality Tests	L.A. Abrasion, Percent Crushed Particles, Flat and Elongated Particles, Film-Stripping (not to be conducted on un-coated aggregate), Cleanness Value and Durability	Perform daily Flakiness Index test, obtain sample from first load.	Deleterious Material, Decantation, Flakiness Index, L.A. Abrasion, MgSO ₄ Soundness, Micro-Deval Abrasion, Aggregate Angularity, Dry Loose Unit Weight, Pressure Slaking, Freeze-Thaw Loss, and 24-hour Water Absorption tests
Asphalt Binder/Emulsion Testing	For Emulsions: Saybolt-Furol Viscosity, Sieve Test, 24-hour Storage Stability, Residue by Distillation, Particle Charge, Penetration at 25°C and 4°C, Ductility, Solubility, Torsional Recovery, Ring and Ball Softening Point (last two are for polymer-modified emulsion). For Asphalt Rubber Binder: Descending Viscosity, Viscosity at 375°F, Cone Penetration and Resilience at 25°C, Softening Point.	QC testing is the responsibility of the bituminous material supplier. Random sampling is arranged by the MnDOT Chemical Laboratory.	For Asphalt Cements: Aged Viscosity, Penetration, and Virgin Viscosity. For Cutback Asphalts: Viscosity, Flash Point, Distillation, Specific Gravity (for in-field temperature-volume corrections), and Penetration/Ductility. For Emulsions: Viscosity, Sieve Test, Demulsibility, Distillation, Penetration, Ductility, and Float Test.
Binder Application Rate	Measured once per 500 gal.	Not specified.	Not specified.

The visit allowed for case study documentation based on interviews of Caltrans, contractor, and third-party quality assurance staff. It also included plant and construction inspection, observation of materials sampling procedures and handling with chain of custody, collection of construction and inspection processes and records, as well as photographs of the practices used during construction.

The mix design consisted of a PG64-16M asphalt rubber binder applied at a rate of 0.58 gal/yd² and a temperature of

385-415°F with pre-coated 3/8 inch single-size aggregate chips. The pre-coating was with 0.5-1.0% of an unspecified asphalt binder and applied at a rate of 35±1 lb/yd². The surface was finished with a flush coat or sand seal. It consisted of an SS-1h emulsion sprayed at 0.12 gal/yd² followed by a cover of sand. The sand gradation and application rate were not specified but indicated to be adequate to eliminate tracking.

The Caltrans field inspector continuously monitored application rates

Table 4. Agency Acceptance Sampling and Testing Requirements.

Test Type	Caltrans	MnDOT	Spokane County	TxDOT
Mix Design (Pre-Production)	Not specified.	Review and verify submitted Mix Design by performing gradation and quality tests.	Not specified.	Sample aggregate from stockpiles and test for Dry Loose Unit Weight, Bulk Specific Gravity, and aggregate spread rate via the "Board Test."
Production Gradation	Once per 300 tons or one day's production.	Stockpile: 1 prior to project beginning Placement: one per day obtained from Contractor's split sample from Spreader Hopper.	Used for acceptance. Sampling rate not specified.	Not specified.
Aggregate Quality Tests	Not specified.	Stockpile: Perform Flakiness Index test and additional quality tests at Engineer's discretion. Production: Perform daily quality tests at Engineer's discretion.	Not specified.	Not specified.
Sand Equivalent	Once per 300 tons or one day's production.	Not specified.	Not specified.	Not specified.
Asphalt Binder testing	Not specified.	First load, then once per 50,000 gal.	Not specified.	Not specified.
Asphalt Binder Application Rate	Not specified.	Verify Application rate. Once per day.	Not specified.	The binder application rate must not vary by more than 0.03 gal/yd ² on three consecutive shot lengths or by more than 0.05 gal/yd ² on any shot length.

based on tanker and truck tickets along with roadway geometry to ensure application rates were within specification. Figure 1 shows a sample of the inspector's calculations. The equipment that was used on the project appeared to be key to quality construction. The binder distributors were equipped with an emission capture device, which are required due to the high application temperatures as shown in Figure 2.

Other equipment included two chip spreaders (one for construction and one as a backup), two pneumatic-tire rollers, one single steel-drum roller (Figure 3),

seven sweepers, thirteen haul trucks, an emulsion distributor, and a sand spreader truck that was actually designed for agricultural applications. It is important to note that a portable asphalt rubber binder blending plant had to be used for the project and was staged at the hot mix asphalt batch plant location where the pre-coated chips were produced 45 miles from the actual project. An asphalt binder tanker with agitation was staged approximately in the middle of the project and used to fill the binder distributors within minutes of the location of their use on the project.

Station	From	To	Area (sq ft)	Rate (gal/sq ft)	Quantity (gal)
120.0	120.0	120.5	1849	3390	61.3
120.5	121.0	2640 x 16.5	4367	85.8	
121.0	121.5	2640 x 16.25	4267	85.8	
121.5	122.0	2640 x 16.4	4311	86.6	
122.0	122.5	2640 x 15.5	4080	79.2	
122.5	123.0	2640 x 15.5	4080	79.2	
123.0	123.5	2640 x 17.75	4680	92.9	
123.5	124.0	2640 x 17.5	4620	91.6	
124.0	124.5	2640 x 17.5	4620	91.6	
124.5	124.6	528 x 17.5	924	18.3	
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Figure 1. Photograph. Example of inspector's calculation worksheet.



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Figure 2. Photograph. Binder distributor with emissions capture device.



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Figure 3. Photograph. Single-Drum Steel-Roller.

All of the equipment was expected to be calibrated upon arrival at the job. The calibration was indirectly verified by comparing materials application rates from the covered area and the quantities delivered based on the truck tickets.

The ambient air temperature at the beginning of construction was 52°F and the pavement surface temperature of 56°F, both of which are slightly lower than the standard, although as construction took place in July, there was little concern of not achieving proper curing. The surface preparation activities included limited dig out repairs and crack filling. The pavement appeared to be in relatively good condition. Any structural deficiencies were effectively repaired by the dig outs.

The project inspection process also included careful monitoring of application rates and temperature ranges. The driving lanes and shoulders were treated separately with the driving lane always treated first. The asphalt distributors began application on the lanes, covering the full 12-foot width in one pass.

Construction joints always started and ended on builder paper. A second full distributor was ahead of the first, prepared to begin application once the first distributor was empty. The chip spreader followed immediately behind the distributor and uniformly spread the pre-coated chips. Application of both the asphalt binder and chips resulted in very uniform coverage.

The rolling operation proceeded rapidly with two pneumatic rollers and a single-steel-drum roller. The rollers engaged in an overlap pattern and performed two

passes for one complete coverage. The final rolling was conducted with a steel-drum roller and consisted of two coverages.

Key practices that led to a quality Caltrans chip seal project included:

- Proper project selection and pre-construction repairs.
 - Mitigates potential for early distresses.
- Conducting a mix design using project specific materials.
- Specifying a maximum L.A. Abrasion of 25%.
 - Prevents excessive wear in the wheel paths due to chains and studded snow tires.
- Proper inspection based on the site-specific conditions.
 - Allows for inspection tasks to be adjusted to accommodate the individual needs of multiple projects across the state.
- Using asphalt rubber binder with pre-coated aggregate
 - Reduces potential chip loss.
- Proper equipment calibration.
 - Ensures proper application at the target rates.
- Continuous inspection.
 - Ensures uniformity and quality.
- Effective communication between Caltrans and the Contractor
 - Allows both entities to work together to achieve a successful project.

Case Study: Spokane County Chip Seal Project

This case study is based on a site visit of multiple chip seal projects including a day on an on-going project in August of 2016. The following information was obtained from an on-site interview and

inspection. This information includes mix design, surface preparation, equipment, and construction practices.

One of the projects was constructed in 2015 on Hayford Road in Spokane, Washington. The roadway is an asphalt concrete arterial with an aggregate and hot-mix asphalt plant along the route. The ADT is approximately 16,000 vehicles per day with 20% truck traffic. The project shows minimal signs of distress, as can be seen in Figure 4.



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Figure 4. Photograph. Photo of the finished Hayford Road project.

Spokane County uses the McLeod Method to develop baseline materials application rates. The application rates may be adjusted later in the field, depending upon project conditions. The mix design records (target application rates) were not collected. For this project, a CRS-2P emulsion was used with 3/8-inch basalt aggregate chips. The final step included a CSS-1h emulsion fog seal, a practice not included in the specifications though fairly often applied. Spokane County performed crack sealing with a

rubberized sealer one year prior to constructing this project. Patching is also performed at the same time, if needed. Patches consist of 3/8 inch hot-mix asphalt (HMA).

Spokane County owns and uses two emulsion distributors, two aggregate spreaders, three pneumatic tire rollers, a static steel drum roller and multiple end dump trucks on most projects. Spokane County calibrates and maintains the equipment. During placement, emulsion is sprayed four inches past the pavement's edge and joints are overlapped by four to six inches with emulsion.

Key practices that led to quality Spokane County chip seal projects included:

- Using basalt quarries with very high-quality rock.
 - Self-performing construction.
 - Gives agencies more control over materials, equipment, and construction practices.
 - Crack sealing one year prior to chip seal construction.
 - Ensures that the crack seal treatment will have adequate curing time to prevent it swelling beneath the chip seal treatment.
 - Using equipment with updated technologies.
 - Metering and pumping systems, thermometers, etc.
 - Ensuring that equipment is properly maintained and calibrated.
 - Verifies proper application rates and uniformity.
 - Ensuring that chip seal crew personnel are frequently trained, even with high employee turn-over.
 - All crew members will be competent and aware of the chip seal construction workflow and procedures needed to ensure proper quality.
- Using a steel drum roller.
 - Improved surface treatment appearance.
 - Special shoulder treatment.
 - In locations with heavy bicycle traffic, 1/2 inch chips are used in the lanes and 3/8 inch chips are used on shoulders to improve ride quality for bicyclists.

State-of-the-Practice

The recommended state-of-the-practice for chip seal preservation treatments includes:

- Selecting quality asphalt binder and aggregate materials.
 - Emulsion or paving grade, based on climate conditions.
 - Tough and abrasion resistant aggregates.
- Performing a mix design as a basis for determining application rates.
 - The McLeod method is a common mix design method that allows for modifications.
- Calibrating equipment with the materials to be used during construction.
 - Recommended to be done prior to every project.
- Proper surface preparation to achieve a clean surface to obtain bond between the pavement surface and the chip seal.
 - Pre-sealing the roadway ahead of chip seal construction.
 - Prevent the crack sealing material from swelling under the new treatment.
 - Paver patching as a part of surface preparation.

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- Mitigate the effects of surface depressions (rutting, potholes, etc.) on the newly constructed treatment.
 - Constructing a test strip.
 - Recommended to be done on every project, under conditions similar to those that are anticipated during construction.
 - Training of chip seal crews and inspectors.
 - Ensure that all members of the crew possess the knowledge required to construct a quality treatment.
 - Inspectors can perform duties necessary to achieve quality product.
 - Enforcing appropriate climatic conditions during construction.
 - The enforcement of wintertime construction shut-down, especially in wet-freeze climates.
 - No impending precipitation within, typically, the next 24 hours to 72 hours.
 - Specifying maximum surface temperature.
 - Inspection of binder application rate and temperature.
 - Chip retention can be achieved.
 - Requirements for contractor QC testing during construction.
 - Aggregate Gradation, L.A. Abrasion, Flakiness Index, asphalt binder quality testing.
 - Requirements for agency Acceptance sampling and testing during construction.
 - Accepting binder based on Certificate of Compliance.
 - Aggregate gradation most common.
 - Verifying Contractor QC data and mix design.

Additional Information

For additional information, contact this project's principal investigator Elie Y. Hajj, Ph.D. at the University of Nevada, Reno.

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