Chip Seals
State of the Practice

2008 Rocky Mountain Pavement Preservation Partnership Conference

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References


Web Contacts

Australia

- Roads and Traffic Authority (RTA, NSW)
  www.rta.nsw.gov.au
- Road Corporation (VicRoads, Victoria)
  www.vicroads.vic.gov.au

New Zealand

- Transit New Zealand (TNZ)
  www.transit.govt.nz
Chip Seals

Workhorse of Pavement Preservation
Pavement Preservation

**Definition:**

“Program employing a network level, long-term strategy that enhances function pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety, and meet motorist expectations”
Preventive Maintenance Concept

The graph illustrates the concept of Preventive Maintenance with different stages of performance (Excellent, Good, Fair, Poor, Very Poor, Failed) and associated costs. The x-axis represents the life cycle, while the y-axis shows the PCI (Performance Condition Index) values. Key points include:

- **40% Drop in Quality**:
  - **75% of Life**: This is the point where a significant drop in quality is observed, suggesting the need for intervention.
  - **12% of Life**: This is a critical point where additional spending of $6 to $10 on rehabilitation or reconstruction is recommended to avoid failure.

The graph emphasizes the importance of timely maintenance to prevent costly failures.
Where are Chip Seals Used?

Lane Miles

- Australia: 136,416
- Canada: 39,482
- NZ: 35,950
- UK: 106,575
- US: 139,713
Chip Seals - Advantages

- Cost-Effective Treatments
- Good Durability
- Ease of Construction
- Improved Skid Resistance
Chip Seals - Disadvantages

- Cure Time
- Flying Chips
- Noise Considerations
- Weather Considerations
- Performance
Chip Seal Programming
Different Purposes

North America
- Distress
- Prevention of water infiltration

Overseas
- Low skid numbers
- Need for wearing surface
# Evolution of Chip Seals

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<th>Characteristic</th>
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<tr>
<td>Outcome</td>
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Chip Seal Service Life

- United States: 5.76 years
- Canada: 5.33 years
- AU, NZ, UK, SA: 9.60 years
Chip Seal Design
Potential Improvement

The greatest potential for improvement is in the area of design - accurate characterization of the surface to measure macro-texture and hardness allows suitable binder types to be chosen and aggregate gradations that are compatible with the surface.

.... Reference 3 (Douglas Granberg’s Paper)
Chip Seal Design Methods
Two Philosophies

Empirical (Art)
- Past experience (Art)
- Purchased as bulk commodity

Engineered (Science)
- Engineering algorithms
- Highly customized
Chip Seal Design Methods (1)

North America

(Ranked by prevalence)

- Empirical / Past Experience
- No Design
- Own Method
- McLeod (1960s) / Asphalt Institute
- Kearby (1953) / Modified Kearby
- Hanson (1934 / 1935)(Obsolete)
Hanson Method (1934 / 1935)

- Earliest formal method
- Developed for liquid asphalt (cutback)
- Based on average least dimension (ALD)
Kearby Method (1953)

- Binder rate based on average thickness, aggregate embedment, voids
- Recommended uniformly graded aggregates
- Embedment based on aggregate hardness (increase for hard, decrease for soft)
- Larger aggregates / less embedment - high ADT
- Medium aggregate/ more embedment - low ADT
McLeod Method (1960s)
(Most Common)

- Officially adopted by Asphalt Institute in 1969
- Based partially on Hanson
- Aggregate rate based on gradation, specific gravity, shape, wastage/correction factors
- Binder rate based on aggregate gradation, pavement condition, traffic volume, asphalt type (absorption)
- Marks effective end of chip seal design research
Chip Seal Design Methods (2)
Overseas

- Kearby and McLeod (1953)
- UK TRL Road Note 39 (1996)
- AustRoads (2001)
- New Zealand P17 (Mod of Australia)
- TRH 3 (Hybrid of UK & Australia)
Road Note 39 Procedure

- Binders selected based on viscosity
- Polymer-modified binders encouraged
- Binder grade based on traffic, season
- Aggregate size based on traffic, pavement hardness, desired friction
- Binder rate based on aggregate, surface texture, embedment by traffic
- Aggregate rate based on size, shape, relative density
AustRoads Sprayed Seal
Design Method

- Performance-based method
- Binder and aggregate rates based on
  - Aggregate angularity
  - Traffic volume
  - Road geometry
  - Aggregate ALD
  - Aggregate absorption
  - Pavement absorption
  - Texture depth
- Aggregate one layer thick
New Zealand P17
Design Factors

Aggregate
  - Size
  - Angularity
  - Average Least Dimension
  - Absorption
  - Embedment

- Traffic volume
- Road geometry
- Pavement absorption
- Texture depth
- Application immediacy (2nd seal)
South African Method
Technical Recommendations for Highways (TRH 3)

• Used on roads up to 50,000 ADT

• Primary inputs: Traffic, preferred texture depth, surface hardness

• Adjustments made for climate, gradients, existing coarse texture, hot applications, preferred aggregate matrix, polymer-modified binders

• Hybrid of Road Note 39 and AustRoads
Formal Design Factors

- Surface texture
- Traffic conditions (ADTs, speed, % commercial, etc.)
- Climate, season
- Chip seal type
- Aggregate selection
- Binder application rate
- Daily construction hours
Single Chip Seal
Double Chip Seal
Racked-in Seal

- Choke Stone (applied dry)
- Uniformly Graded Aggregate
- Binder Application

Existing Asphalt Pavement
Cape Seal
Inverted Seal
Sandwich Seal (Dry Matting)
Geotextile-Reinforced Seal
Chip Seal Materials
Common Aggregate Sizes

Single Chip Seals
  • 3/8” (10mm)

Double Chip Seals
  • ½” (12.5mm) (First App)
  • ¼” (6.25mm) (Second App)
Pre-Coating Aggregates

- Improves binding properties
- Reduces dust
- Enhances visibility of markings
- Decreases required curing time
- Decreases chip loss
- Not used with emulsion binders (inhibits breaking of emulsion)
Aggregate Performance

Best performance from

- Single sized (if possible)
- Minimum fines (<2% #200)
- Clean
- Free of clay
- Cubical (limited flat particles)
- Crushed faces
- Abrasion < 30%
- Binder-compatible
- Damp for emulsions
- Dry for hot binders
Overseas Aggregate Use

- Basalt, quartzite, granite most common
- Washed in water or kerosene
- Crushed to cubical shape
- Single applications - 10mm
- Uniform gradation
- Double applications - 12.5mm/6.25mm
- Angular shapes problem for turners
- Polished Stone Value (PSV): 44-48
- Some pre-coated with liquid asphalt
Binder Properties

- No bleeding when applied properly
- Cover surface w/o puddling, runoff
- Develop adhesion quickly
Binder Selection

Influenced by:

- **Surface temperature**
  - High - asphalt binders
  - Low - emulsions

- **Aggregate**

- **Construction climate**
Best Materials Practices

• Electrostatic chip testing before design
• Uniformly graded, high quality aggregates
• Lightweight aggregate to minimize vehicle damage
• Life Cycle Cost analysis to evaluate aggregate importation
• Polymer-modified binders for performance
Chip Seal Equipment
Water Re-Texturizing Machine
Surface Cleaning with Truck-Mounted Cutting Heads
Umbilical Ultra-High Pressure Water-cutter
Cleaned Surface
Distributor Spray Bar
Distributor Rate Control Computer
Dump Truck Spreader
Self-Propelled Aggregate Spreader
Low Drop Aggregate Spreader
Aggregate Pre-coating Loader
Pneumatic Roller
Rotary Broom (1)
Rotary Broom (2)
Best Equipment Practices

- Computerized distributors for greater control
- Matching chip seal equipment with distributor (speed of operation)
- Variable nozzles to reduce binder in wheel paths
- Plastic broom bristles to reduce aggregate dislodgement
- Water re-texturing machines to remove irregularities, bleeding
- Use of vibratory pneumatic rollers
Chip Seal Construction
**Ideal Weather Conditions**

- **Air temperature**: High
- **Relative humidity**: Low
- **Wind velocity**: None
- **Precipitation**: None

*(Low humidity critical for hot asphalt binders)*
Pavement Preparation

- Texturizing
- Patch and Level
- Fog Coat
- Crack Sealing
- Fresh Pavement

Legend:
- North America
- AU, NZ, UK, SA
Binder Application
Spreading Aggregate
Excess Aggregate

The Montana field-sweeping test (*Maintenance Chip Seal Manual* 2000) curtails the bias to spread excess aggregate created by paying for it by the ton. Montana requires that the amount of excess chips be less than 10% of the design rate and adjusts the pay quantities based on the sweeping test results. This may also reduce the potential for windshield damage claims.
Rolling
Sweeping (1)
Sweeping (2)
Best Construction Practices - (1)

- Application in warmest, driest weather
- Ambient air temperatures
  - Emulsions (50F-110F)
  - Asphalt cements (70F-110F)
- Surface temperatures
  - Emulsions (70F-140F)
- Lead times
  - Patches 6 months
  - Crack seals 3 months
- Variable nozzles to prevent bleeding
- Roller 1 drags broom
- Prompt aggregate application
- Excess aggregate penalty
Best Construction Practices - (2)

- Racked-in seals for problem areas
- Rolling rates based on aggregate size, traffic (3,000-5,000 sq yd/hr)
- N rollers based on distributor production, rolling times
- Roll close to spreader
- Maintain traffic control to allow curing
- QC/QA only by experienced personnel
- Regular calibration of distributor, spreader
- Field test aggregate-binder compatibility
- Sample / test binder, aggregate at distributor, stockpile respectively to detect degradation
Chip Seal Contracting
Types of Chip Seal Contracts

- United States: 94% Unit Price-Low Bid, 6% Lump Sum-Low Bid
- Canada: 100% Unit Price-Low Bid
- AU, NZ, UK, SA: 86% Unit Price-Low Bid, 71% Lump Sum-Low Bid, 22% Design-Build
Typical Project Lengths

- AU, NZ, UK, SA: 42 miles
- Canada: 18 miles
- United States: 17 miles
Warranty Requirements

- United States: 19% Yes, 81% No
- Canada: 11% Yes, 89% No
- AU, NZ, UK, SA: 100% Yes, 0% No
Contract Risk Continuum

- Input Driven: Maximum Risk Owner
  - Owner Designed
  - Prescriptive Specification
  - Owner’s Construction Methods
  - Construction Unwarranteable

- Output Driven: Owner or Contractor Designed
  - Prescriptive Specification
  - Contractor’s Construction Method
  - Construction Warranteable

- Performance Driven: Contractor Designed
  - Performance Specification
  - Contractor’s Construction Method
  - Long-Term Warranteable

- Maximum Risk Contractor
Best Contracting Practices

• Let chip seal contracts to allow early season construction
• Allow enough time for curing of pre-construction preparation
• Make jobs large enough to attract bidders
• Restrict warranties to jobs where contractors have sufficient control
Chip Seal Performance Measures
Performance Measures
(Quantitative)

- Cannot use traditional performance measures of asphalt pavements
- Skid Resistance based on
  - Micro-texture (Aggregate frictional properties)
  - Macro-texture (Particle size, shape, spacing)
- Texture Depth (TD)
  - Measured by Sand Patch Test (ASTM E965)
  - NZ P17 “… design life…reached when TD falls below 0.9mm on roads with V>70 kph”
Performance Measures
(Qualitative)

- Visual surface ratings
- Visual chip seal distress
- Bleeding
- Raveling
- Defects
- Ohio visual evaluation
Needed Research

- Designs based on engineering principles
- Macro-texture, surface hardness tests
- Inverted seals to correct bleeding
- Racked-in seals for problem areas
- Economics of retexturing
- Pre-coating aggregates
- Drop chip spreaders
- Rollers and their operations
- Chip seal warranties
- Chip seals and noise
- Standard chip seal glossary, standard specification
Need More Information?

- National Center for Pavement Preservation at Michigan State University

www.pavementpreservation.org
Thank You