Chip Seals
Theory and Best Practices
Leading To A Successful Project
Edward J. Denehy, P.E.
Edward J. Denehy, P.E., MPA, BSCE

- 5+ years, The Gorman Group
- 36+ years, NYSDOT
- 19 years as Statewide Pavement Preservation Engineer
- Panel Chair for Transportation Research Board Chip Seal Research Project
- Member FHWA Expert Task Group on Pavement Preservation
- Founding member and past Chair of Northeast Pavement Preservation Partnership

www.gormanroads.com
Chip Seals – Presentation Outline

- Description
- Project Selection
- Chip Seal Mix Designs
- Recap of Chip Seal Research
Chip Seals – Presentation Outline

- Conventional Emulsion Based Single Chip Seal Specifications
  - Material Requirements
    - Emulsion
    - Aggregate
  - Weather and Seasonal Requirements
  - Equipment Requirements
  - Work Zone Traffic Requirements
  - Construction Requirements
Chip Seals – Presentation Outline

- Chip Seal Variations
  - Double Chip Seals
  - Triple Chip Seals
  - Cape Seals
  - FiberMat
Chip Seals – Description

- An application of emulsified asphalt
- Followed by application of aggregate
- Which is then rolled and broomed
Chip Seals – Characteristics

- Protects the underlying pavement
- Waterproofs the road’s surface
- Seals small cracks
- Improves surface friction
  - Improves safety by improving skid resistance
- Extends service life
Chip Seals – Project Selection

- Pavement in good or better condition
  - Low volume traffic only (< 2000 AADT)
  - Low to moderate truck traffic (< 10%)
  - Low extent and severity cracking (<1/8”), raveling, or rutting (<3/8”)
  - Infrequent corrugations, settlements, heaves, or slippage cracks
Chip Seals – Mix Designs

- Mix Design appears to be more art than science
- Empirical designs require field adjustments of emulsion application rates
- Earliest Mix Design by Hanson, 1934-1935
- Subsequent efforts by Hanson (1953) and McLeod (1969) incorporated by Asphalt Institute (1979) as one “standard”
Chip Seals – Mix Designs

- Efforts by Kearby (1953), refined by Benson (1955) and Epps (1981) became another “standard”
- Both methods use lab tests to determine aggregate and emulsion quantities based on aggregate sizes
- Use correction factors for season, traffic, temperature, pavement surfaces, etc.
Chip Seals – Mix Designs

- Use of judgment in applying correction factors requires experienced field personnel
- Art versus science
Chip Seals – Mix Designs

- Improvements in design – NCHRP 680
  - Sand patch or Circular Track (CT) meter to obtain surface texture
  - Ball penetrometer to determine if aggregate will penetrate substrate
  - Moisture content to determine time until sweeping
  - Embedment depth during construction – Glass bead test
  - Emulsion field viscosity
Chip Seals – Research

- **Surface Treatments**
  - Use began in the 1920’s
  - Primarily as hard surfaces for gravel roads
- **Hanson, 1934-1935**
- **Hanson (1953) and McLeod (1969) morphs into Asphalt Institute (1979) method**
- **Kearby (1953), Benson (1955) and Epps (1981) morphs into another method**
Chip Seals – Research

- NCHRP Synthesis 342 – Chip Seal Best Practices – Gransberg and James, 2005
- WSDOT Chip Seals – Optimal Timing, Design and Construction Considerations, 2014
Chip Seals – Materials

- **Emulsion**
  - Traffic Volume <500 AADT
    - Conventional Emulsions
      - RS-2, HFRS-2, CRS-2
  - Traffic Volume >500 AADT
    - Polymer modified emulsions recommended
      - HFRS-2P, CRS-2PM
Chip Seals – Aggregates

- One size – either 1A or 1ST per project requirements
- Cubical
- Clean – less than 1% dust
- Angular – crushed
- Hard – abrasion resistant
## Chip Seals – Aggregate Gradations

<table>
<thead>
<tr>
<th>Screen</th>
<th>% Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>½ inch</td>
<td>100</td>
</tr>
<tr>
<td>¼ inch</td>
<td>0 - 15</td>
</tr>
<tr>
<td>#200</td>
<td>0 - 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Screen</th>
<th>% Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>½ inch</td>
<td>100</td>
</tr>
<tr>
<td>¼ inch</td>
<td>90 - 100</td>
</tr>
<tr>
<td>1/8 inch</td>
<td>0 - 15</td>
</tr>
<tr>
<td>#200</td>
<td>0 - 1</td>
</tr>
</tbody>
</table>

[www.gormanroads.com](http://www.gormanroads.com)
Chip Seals – Weather and Seasonal Requirements

- **NYSDOT Specifications**
  - Chip Seals allowed May 1 thru September 7
  - No standing water
  - Surface temperature > 60 degrees F
  - Ambient temperature > 50 degrees F

- **Traffic sets aggregate in final position**
  - Need enough warm weather to do so
Chip Seals – Equipment

- Power brooms
- Bituminous Material Distributor
- Aggregate Spreader
- Pneumatic Tire Rollers
Chip Seals – Equipment

- Power brooms
  - Rotary broom to clean pavement
  - Pick-up sweeper to sweep completed chip seals
Chip Seals – Equipment

- Bituminous Material Distributor
  - Calibrated
  - Variable Width up to 15 feet
  - Full circulation spray bar, adjustable horizontally and vertically
  - Nozzles at 15-30 degree angles, nozzles working
  - Triple lap
  - Tachometer, accurate measuring device or calibrated tank, thermometer, sampling valve
Chip Seals – Equipment

- Aggregate Spreader
  - Self-propelled
  - Calibrated for each project, preferably every day
  - Uniform spread rate
  - Capable of spreading aggregate 6 inches wider than lane width being treated
Chip Seals – Equipment

- Pneumatic Tire Rollers
  - Self-propelled
  - Oscillating, smooth tires
  - 80 psi
- Number of rollers (5 ft wide) by chip seal width
  - <6 feet: 1 roller
  - 6 to 9 feet: 2 rollers
  - 9 to 12 feet: 3 rollers
  - 12 to 15 feet: 4 rollers
Chip Seals – Work Zone Traffic Control

- Close lane being worked on, alternate one way traffic on open lane
- Use Pilot vehicle to control low speed traffic (<15 mph for 3 hours minimum) on completed chip seal
- Supply enough flaggers for intersecting roads, driveways, etc.
- Post road for 30 mph for minimum 7 days
- Lightly sweep prior to allowing uncontrolled traffic
- Sweep after 24 hours and as necessary up to 5 days
Chip Seals – Surface Preparation

- Patch holes or fill wheel ruts
- Fog or seal newly patched areas
- Protect manholes, drop inlets, etc.
- Fill or seal cracks
- Remove epoxy and plastic striping
Chip Seals – Emulsion Application

- Contractor supplies mix design which specifies:
  - Quantity and type of emulsion per square yard – usually 0.35 to 0.45 gal/sy
  - Quantity of aggregate per square yard – usually 22 to 26 lbs/sy
Chip Seals – Emulsion Application

www.gormanroads.com
Chip Seals – Aggregate Application

- Aggregate shall be applied immediately after the application of the emulsion as per the mix design
- Typical aggregate application rate
  - 22 to 26 lbs/sy
Depth of emulsion just before chip application

Depth of asphalt binder just after chip application

Depth of emulsion just after rolling

Depth of emulsion after considerable traffic

www.gormanroads.com
Chip Seals – Rolling

- Immediately after aggregate application
  - Start within 5 minutes maximum
- Minimum 3 passes
- Stop rolling after set
Chip Seals – Characteristics

- Protects the underlying pavement
- Waterproofs the road’s surface
- Seals small cracks
- Improves surface friction
  - Improves safety by improving skid resistance
- Extends service life
Chip Seals – Fog and Sand

- Fog seal and sand – single surface treatment
  - Reduces stone loss
  - Retains anti-icing materials near top of aggregate
  - Retains pavement markings better
  - Looks like a hot mix asphalt surface
Chip Seals – Fog and Sand

- Wait approximately 1 week after completion of surface treatment
- Usually only takes 1 day to complete
- Materials
  - Emulsion – HFRS-2h at 0.08 to 0.15 gal/sy
  - Sand – concrete sand at 2 to 5 lbs/sy
Chip Seals – Double Chip Seals

- Two applications of emulsion and aggregates
  - In NY, 1-ST aggregate followed by 1-A aggregate
  - Less noise
  - Tighter surface texture
  - More robust treatment
  - Additional cost, etc.
  - More acceptable to abutting property owners
Chip Seals – Triple Chip Seals

- Three applications of emulsion and aggregates
  - Usually 2 applications of 1-ST type aggregate followed by a 1-A type aggregate
  - More robust treatment, adds some structural strength
  - Used over gravel roads as first step in adding a hard surface
  - Costly
  - Existing gravel may have to be modified to perform well under chip seal
Chip Seals – Cape Seals

- An application of a single chip seal, followed by a micro surfacing or a quick-set slurry seal
- Addresses rough surface texture concerns
- Adds service life and some structural strength
- Adds cost
Chip Seals – FiberMat® – History

- Developed in England in Mid ’80s
- Introduced to USA in 2001
- 4.0 million+ square yards placed to date
- NYSDOT Specification - 2006
Chip Seals – FiberMat® Type A & B

- **Type A**
  Polymer Modified Surface Treatment with fiberglass strands and select aggregate

- **Type B**
  Polymer Modified Stress Absorbing Membrane Interlayer (SAMI) with fiberglass strands and select aggregate.

www.gormanroads.com
Chip Seals – FiberMat® Type A

- To bridge alligator cracking and delay reflective cracking
- To improve skid resistance
- To protect and waterproof sub-base
- To improve tensile strength
Chip Seals – FiberMat® Type A
Chip Seals – FiberMat® Type B

- To add a flexible *interlayer* to absorb movements
- To improve tensile strength
- To bridge alligator cracking and delay reflective cracking
- Retards reoccurrence of wheel rutting when used in conjunction with other asphalt layers
Chip Seals – FiberMat® Type B
Chip Seals – FiberMat® – Fiber Membrane
Chip Seals – FiberMat® Equipment

- Specialized Fiber Applicator
- Asphalt Distributor/Tanker
- Self Propelled Chip Spreader
- Rubber Tired Roller
- Rotary Broom

www.gormanroads.com
Chip Seals – FiberMat® Applicator

www.gormanroads.com
Chip Seals – FiberMat® Fiberglass Storage
Fiberglass Shards

www.gormanroads.com
Chip Seals – FiberMat® – Mechanics
Chip Seals – FiberMat® – Type A

- Polymer Modified Asphalt Emulsion
  - 0.4 – 0.6 gal/sy
- Fiberglass
  - 2 - 4 oz/sy
- Aggregate
  - 20 – 25 lbs/sy
  - #1, #1ST or #1A

www.gormanroads.com
Chip Seals – FiberMat® – Type B

- Polymer Modified Asphalt Emulsion
  - 0.4 – 0.5 gal/sy
- Fiberglass
  - 3 - 4 oz/sy
- Aggregate
  - 12 – 15 lbs/sy
  - #1A

www.gormanroads.com
GROTH ROAD – TOWN OF MURRAY, ORLEANS COUNTY, NY

March 2004

January 2005

January 2006

January 2007

June 2008

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>PROJECT OCTOBER 2003</td>
</tr>
<tr>
<td>2004</td>
<td>EXTENSIVE LONGITUDINAL CRACKS RE-APPEAR</td>
</tr>
<tr>
<td>2005</td>
<td>BAR PATCHING</td>
</tr>
<tr>
<td>2006</td>
<td>AS 2004 PLUS SCALPING OF AGGREGATE</td>
</tr>
<tr>
<td>2007</td>
<td>ADDITIONAL BAR PATCHING</td>
</tr>
<tr>
<td>2008</td>
<td>AS 2005 + WATER PUMPING</td>
</tr>
<tr>
<td>2009</td>
<td>CIPR OR MILL &amp; REPLACE</td>
</tr>
<tr>
<td>2010</td>
<td>AS 2006 + EXTENSIVE EDGE CRACKING</td>
</tr>
<tr>
<td>2011</td>
<td>FULL DEPTH RECLAMATION</td>
</tr>
<tr>
<td>2012</td>
<td>AS 2007 + RAVELLING</td>
</tr>
<tr>
<td>2013</td>
<td>BAR PATCH OR CRACK SEAL</td>
</tr>
</tbody>
</table>
PENNSYLVANIA TRANSPORTATION INST. TEST
SECTIONS – PENN STATE

HMA Sections
- HMA Overlay
- Base
- Cracked HMA

PCC Sections
- Weak Base
- Strong Base
- PCC

FiberMat Type B

FiberMat Type A

A

B

C
Chip Seals – FiberMat® Control Section

Control Section Crack all the way through
Chip Seals – FiberMat® Type B Core

FiberMat Type B Crack Underneath Interlayer
Chip Seals – FiberMat® – Advantages

- Easy to apply
- Opened to traffic quickly
- Waterproofing properties
- Inhibits surface cracking
- Increases tensile strength
- Completely recyclable
- Cost effective

www.gormanroads.com
Chip Seals

“Chip seals may be the most cost effective method available for extending the service life of asphalt concrete pavements.”

Scott Shuler, Colorado State University
Chip Seals – Presentation Wrap Up

- Description
- Project Selection
- Chip Seal Mix Designs
- Recap of Chip Seal Research
Chip Seals – Presentation Wrap Up

- Conventional Emulsion Based Single Chip Seal Specifications
  - Material Requirements
    - Emulsion
    - Aggregate
  - Weather and Seasonal Requirements
  - Equipment Requirements
  - Work Zone Traffic Requirements
  - Construction Requirements
Chip Seals – Presentation Wrap Up

- Chip Seal Variations
  - Double Chip Seals
  - Triple Chip Seals
  - Cape Seals
  - FiberMat
Chip Seals

- Questions?