GREEN TECHNOLOGY:

OPTIMIZING PAVEMENT RECYCLING METHODS IN INGHAM COUNTY

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Why Recycle?

- Utilize Already Paid-For Materials
- Existing Pavement Source of Quality Aggregates
- Reduce Cost, Extend Project Budgets
- Facilitate Improved Pavement Structure
- Conserve Resources
  - Reduce Trucking Costs
  - Reduce Virgin Material Consumption
  - Reduce Energy Consumption
- But Most Important…

RECYCLING SAVES $$

Most Common Pavement Recycling Methods -

- Cold Milling Hot Mix Asphalt (HMA) Pavements
- HMA Base Crushing and Shaping
- Hot-in-Place Recycling (1 – 2 inch partial depth)
- Cold-in-Place Recycling (3 – 5 inch partial depth)
- Full Depth Reclamation (4 – 8 inch depth)

Emerging Technology -

- Ground Tire (Crumb) Rubber Modified HMA Pavements

COLD MILLING HMA PAVEMENTS

Cold Milling HMA Surface

- Traditionally Contractor Property, RAP utilized in Hot Mix Asphalt
  - No Compensation to Owner
  - Material Value Lost

Cold Milling HMA Surface

- Repurposed Uses by Ingham County
  - Maintenance Stockpiles
    - Trucking Cost Not Eligible for Federal Participation
    - Trucking Costs Doubl
    - Trucking Currently Scarce, Expensive

Cold Milling HMA Surface

Recycling HMA Surfaces Special Provision:

- Repurposed RAP Used on the Project Multiplies Cost Savings:
  - Eliminate Trucking Out RAP
  - Reduce/Eliminate Trucking Pit Aggregate In
- Repurpose Material on Nearby Project(s)
  - Trucking Paid Separately (One Way Only)
  - Non-Participating Pay Item
- Coordinate Projects for Efficiency

HMA BASE CRUSHING (AND SHAPING)

HMA Base Crushing (and Shaping)

Same Recycling Principles as Cold Milling

- Separate Crushing from "Crushing and Shaping" (Recycled Aggregate Production)
- All HMA Removals Specified for Recycling (HMA Surface, Rem, Special)
- Stockpiling and Handling Included with Modified or Special Pay Items
- Estimate Available Quantity with Pavement Cores

Recycling HMA Surfaces Special Provision:

Recycled Aggregate Use

- Aggregate Bases

  (Especially Crush & Shape/Widening Projects)
- Stabilized RAP/Aggregate Bases (CIPR, FDR)
- Approach, Cl III
- Shoulder, Cl III
- Subgrade Undercutting
- Embankment
- **Engineer Retains Authority to Restrict Use of All Recycled Aggregates**

Recycled Aggregate Sources

- Project Removals (Crushing/Cold Milling)
- Imported from Off-Site Location(s)
  - Other County Project(s)
  - Processed/Crushed Material Supplier
  - Contractor Yard
  - Other Contractor Projects

Recycled Aggregate Base (Imported)

Aggregate Base, Modified Special Provision:

- 21AA Base Gradation (Imported Aggregate)
- Tolerance Ranges Permit Acceptable Variability
- Testing at Engineer Discretion:
  - At Stockpile (Source) Location
  - On Project
  - Remediation Permitted
- 1/2 the Cost of Virgin (Pit) Aggregate
- Quality Comparable (Better?) than Pit Aggregate

Recycled Aggregate Base

Aggregate Base, Modified Special Provision:

Compensation Strategies

- Separate Pay Items for Different Depths (SYD) (Within X-Section, e.g. Widening)
- Amalgamated Depth Pay Item (SYD)
- Weight (TON) – Requires Scale Tickets
- Volume, LM (CYD)
- Volume, CIP (CYD)??

Recycled Aggregate Base

Aggregate Base, Modified Special Provision:

- Multiple Pay Items = Inspection Intensive

Separate Pay Items for Different Depths

  - Aggregate Base Conditioning (No Grade Change)
  - Aggregate Base, Salv, __ inch (Widening, Cut, Fill)
  - Aggregate Base, RAP __ inch (for Stabilized Base)
- Transition Points Subjective
- Overrun Risk to Owner

Recycled Aggregate Base

Aggregate Base, Modified Special Provision:

- Single Pay Item Regardless of Depth Variation, Either Across X-Section OR Throughout Alignment
  - Aggregate Base, Modified, _ inch
  - Pay Limits Per Typical Section = Reduced Inspection
  - Contractor Assumes Risk for Available vs Imported Material
  - Include Pavement Cores in Contract Docs

Amalgamated (All Inclusive) Depth Pay Item

New Construction
With
Recycled Aggregates
Produced from

- Cold Milling HMA Surface
- HMA Base Crushing

= COST SAVINGS

ICRD Recent Project Savings 2015 Lake Lansing Road, Meridian Twp.

- 1.0 mi, Widen 2 to 3 Lanes, Crush & Shape
- Quantity for Widening Will Be Imported
- Aggregate Base, Modified, 9 inch $ 3.78/SYD
- MDOT Statewide AUP (22A) $ 7.29
- 48% Savings

ICRD Recent Project Savings 2014 Intersection Safety Projects

- Vertical and Horizontal Intersection ReAlignment
- Recycled Aggregate Removed and Replaced on New Alignments

College @ Kipp and Williams @ Decamp

- Aggregate Base, Salv, 7 inch $ 3.28/SYD
- Std Spec (21AA) Aggregate Base, 7 inch $ 6.44
- 49% Savings
- Minimal to No Imported Aggregate

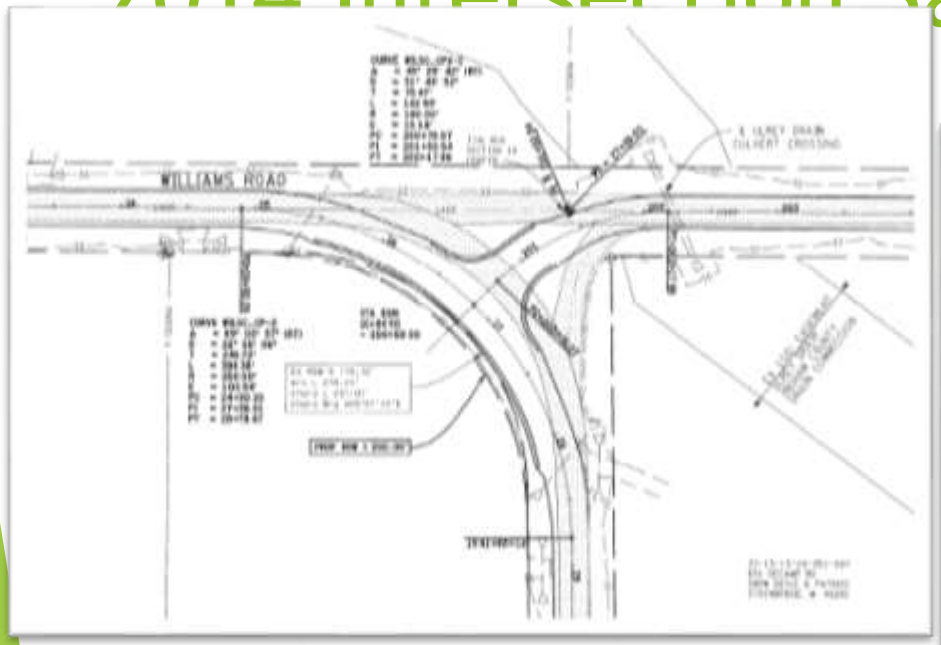
ICRD Recent Projects
2014 Intersection Safety

Before

After

College Rd @ Kipp Rd

ICRD Recent Projects
2014 Intersection Safety



Williams Rd @ DeCamp Rd

ICRD Recent Project Savings 2013 Zimmer Road, Williamstown Twp

- 4 mi Widen for Paved Shldr, Crush & Shape;
- Aggregate Base, Salv, 7 inch $ 3.12/SYD
- Std Spec Aggregate Base, 7 inch $ 6.64
- 53% Savings
- Aggregate Base, Salv, 5 inch $ 2.50/SYD
- Std Spec Aggregate Base, 5 inch $ 4.69
- 47% Savings
- High Quality Recycled Material Imported from State Complex

ICRD Recent Projects
2013 Zimmer Rd

Before

After

Zimmer Rd @ M-43 Grand River Ave

ICRD Recent Projects
2013 Zimmer Rd

Before

After

Zimmer Rd

ICRD Recent Project Savings
2013 Cornell Road, Meridian Twp

- 2 mi, 2 Lane Crush & Shape,
- Over 5,000 CYD RAP Imported from Nearby Marsh Rd Mill/Fill Project (1/2 mi Long Stockpile!)
- Aggregate Base, RAP, LM $ 8.77/CYD
- Trucking $ 2.50/SYD (From Marsh Rd)
- Total In-Place Cost $ 1.56/SYD
  Placed 5” LM (±4” CIP)
- Crumb Rubber Modified HMA

ICRD Recent Projects

2013 Cornell Rd, Meridian Twp

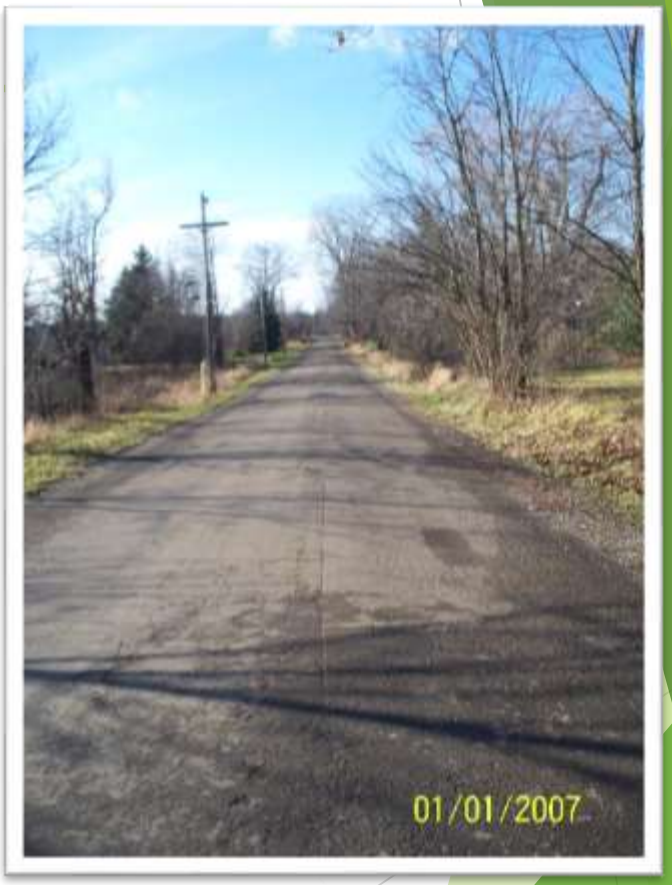
Before

After

ICRD Recent Project Savings
2012 Raby Road, Meridian Twp

- ±0.8 mi, 2 Lane Unpaved Local Rd
- Numerous Resident Dust and Pothole Complaints
- 2,500 CYD RAP Imported from Nearby Haslett Rd CIPR Project
- Graded, Compacted by ICRC Maintenance Crew
- Placed ±8” LM (±6.5” CIP)
- Trucking $ 3.00/CYD (From Haslett Rd)
- In-Place Material Cost $ 0.67/SYD

ICRD Recent Project
2012 Raby Road, Merid



- No More Resident Complaints!

HOT IN PLACE RECYCLING (HIPR)

Hot In-Place Recycling (HIPR)

- HIPR is an On-Site, In-Place Rehabilitation of Existing Pavement Consisting of:
  - Heating (Softening)
  - Rejuvinating (Binder)
  - Mixing
  - Placing
  - Compacting
- Typically 1 to 2 inches in Depth

Hot in Place Recycling (HIPR)

Primary Heater

Hot in Place Recycling (HIPR)

Secondary Heater

Rejuvinating
Oil Distributor

Hot in Place Recycling (HIPR)

Tines & Auger

Screed

Hot in Place Recycling (HIPR)

- Immediate Open to Traffic (1-2 Weeks Max)
- Finished HIPR Surface Requires Surface Course
  - HMA Overlay
  - Chip Seal
- $4-6/SYD (Quantity Dependent)

Compacted HIPR Surface

Hot in Place Recycling (HIPR)

HMA Overlay

Curb Reveal

ICRD 2014 Local Road Program

Hot in Place Recycling (HIPR)

- Advantages:
  - Single Pass Operation
  - Lowering/Adjusting Castings Not Required
  - Immediate Open to Traffic
- Disadvantages:
  - Limited Depth
  - Crown Correction Not Possible
  - Reflective Cracking Eventual
  - Not Suitable with Overband/Hot Poured Joint Sealers

ICRD Recent Project Savings
2014 Shoeman Rd, Meridian Twp

- 2.4 mi Cold Milling, HIPR, and Intersection Grade Raise w/ HMA Base Crushing
- 2,000 CYD RAP Generated from Cold Milling
- Aggregate Base, Salv, 7 inch $ 4.50/CYD
- Aggregate Base, 21AA, 7 inch $ 10.00/CYD
- 31,000 SYD HIPR @ $ 4.24/SYD
- Maintained Traffic for 8 weeks (NOT Recommended!)
- Surplus RAP Hauled to Unpaved Local Road

ICRD Recent Projects
2014 Shoeman Rd

Texture

HIPR Surface

ICRD Recent Projects

2014 Shoeman Rd

RAP Surfaced Local Road

Grade Raise

COLD IN PLACE RECYCLING (CIPR)

What is Cold-in-Place Recycling (CIPR)?

- In-Place Resurfacing Using Existing Materials with No Heat
- Partial Depth Cold Milling, Bituminous Stabilization Processing, and Repaving in a Single Pass
- Removes Distress at Depths Up to 5 inches
- Requires Wearing Course
  - HMA – Higher Volume Roads
  - Chip, Cape Seal or Micro Surfacing - Lower Volume Roadways

Cold-in-Place Recycling (CIPR)

- Distresses that can be treated with CIR
  - Thermal Cracking
  - Fatigue and Edge Cracking
  - Reflective Cracking
  - Rutting
  - Raveling
  - Poor Ride Quality

Cold-in-Place Recycling (CIPR) Process

- Cold Mill 3 – 5 inches Deep
- Inject Binder/Stabilizing Agent
- Mix All Components
- Re-Pave with Treated Recycled Mixture
- Compact and Cure Recycled Mixture
- Apply Wearing Course

Cold-in-Place Recycling (CIPR)

Types of Stabilization Agents

- Bituminous Stabilization:
  - Conventional Emulsion
  - Engineered Emulsion
  - Foamed Hot AC
- Chemical Stabilization (Pozzolanic), e.g. Cement (Usually an Additive)

Cold-in-Place Recycling (CIPR)

- Types of Stabilization Agents

- Conventional Asphalt Emulsions
  - Mechanical Break
  - Graded for Seal Coat Specifications
  - Temperature and Moisture (Weather) Sensitive
  - Longer Cure Time / Delay Open To Traffic
  - Cost Effective

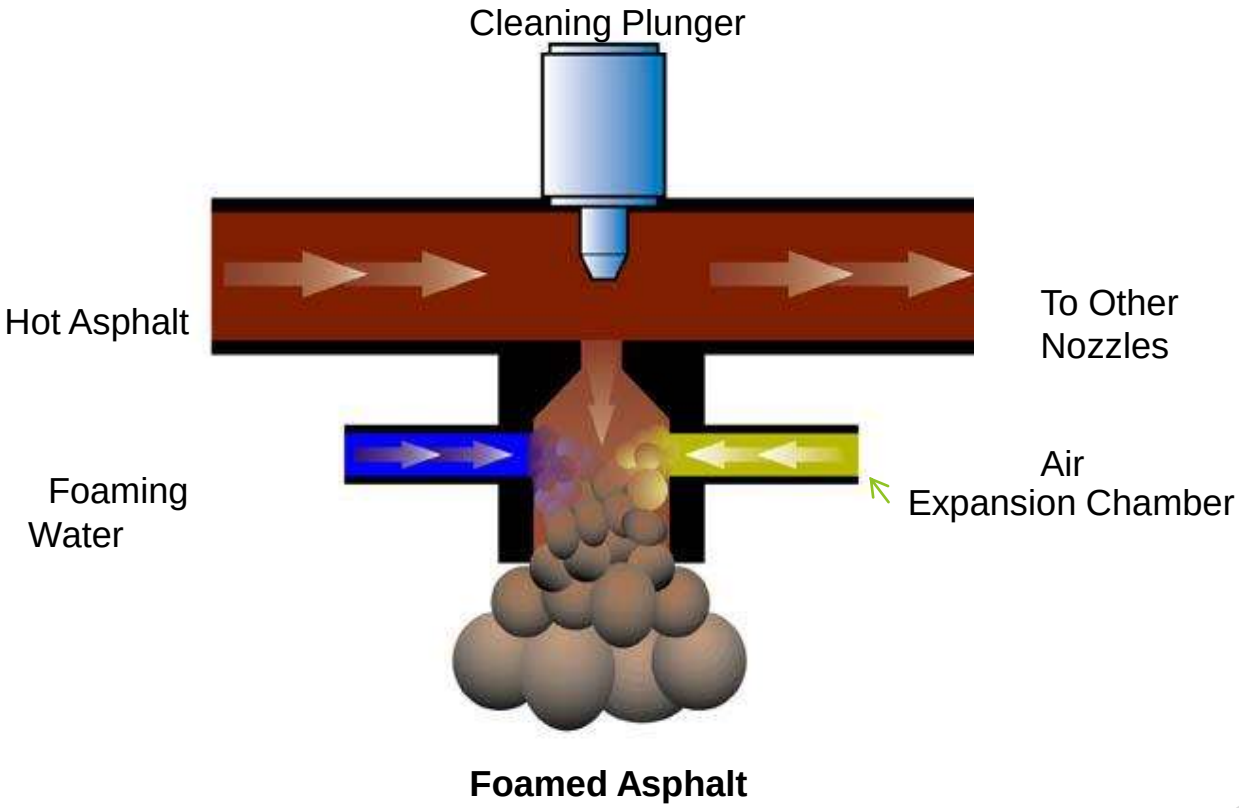
Cold-in-Place Recycling (CIPR) - Types of Stabilization Agents

- Engineered Emulsion
  - Higher Asphalt Content
  - Durability
    - Flexible
    - Climate-Specific Binder
    - Formulated for Each Project
    - Faster Cure (vs Conventional Emulsions)
  - Better Dispersion with Higher Film Thickness

Cold-in-Place Recycling (CIPR) - Types of Stabilization Agents

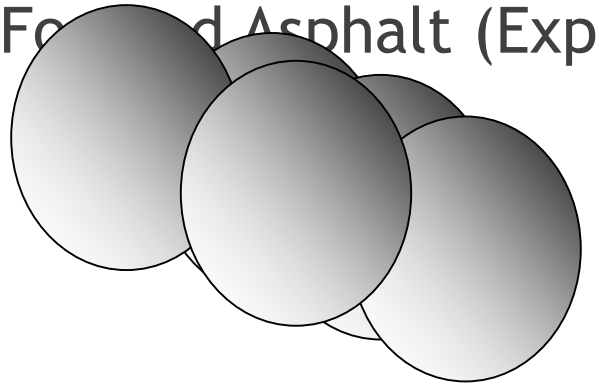
- Foamed Asphalt (Expanded Asphalt)
  - Water (± 2% by Weight) Injected into PG Grade Hot AC (350° F)
  - Water Evaporates Abruptly; Causes Explosive Foaming in the Asphalt Stream
  - Asphalt Expands 15 To 20 Times Original Volume

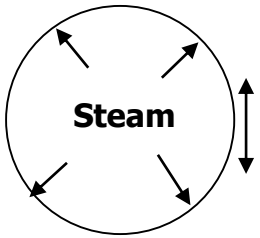
Wirtgen Asphalt Foaming



Cold-in-Place Recycling (CIPR) - Types of Stabilization Agents

Fo d Asphalt (Expand





Cold-in-Place Recycling (CIPR) Process

- Repaving Treated Material
  - Conventional Asphalt Paver (Preferred)
  - Screed w/Electronic Grade & Slope Controls
  - Elevator Loads Paver Hopper
  - Maintain Constant Material Depth
  - 30 Ft Averaging Ski for Smooth Ride
  - Keep Paver Close to Mixing Unit

Cold-in-Place Recycling (CIPR) Process

- Repaving Treated Material
  - Some Equipment Has Integral Paving Screed
  - Material Handling Capability Limited
  - Not Suitable for Crown Correction or Widening Pavement

Cold-in-Place Recycling (CIPR) Equipment

- Types of CIR Trains
  - Single Unit Train
  - Two Unit Train
  - Multi Unit Train

Cold-in-Place Recycling (CIPR) Equipment

- Single Unit Train (Preferred)
  - "Down-Cut" Mill Controls Gradation
  - Mill Cuts Existing Pavement to Proper Depth and Slope with Electronic Controls
  - Spray Bar in Cutting Chamber Injects Binder, Water, Additives into Mix with Computer Controlled System
  - Treated Material Windrowed Between Processing Unit Tracks

Cold-in-Place Recycling (CIPR) Equipment

Single Unit Train

Cold-in-Place Recycling (CIPR) Equipment

Cold-in-Place Recycling (CIPR) Equipment

HMA PAVER

Cold-in-Place Recycling (CIPR)

Two Unit Train

Cold-in-Place Recycling (CIPR)

Multi-Unit Train

Cold-in-Place Recycling (CIPR) Equipment

- Compaction
- CIPR Mixes are Stiffer, Placed in Thicker Lifts; Heavier Rollers Required for Compaction
- Compaction Follows Emulsion Break (Color Change)
- Water System Prevents Mix from Sticking to Rollers
- 95% - 102% Density as Determined by Growth Curve

Cold-in-Place Recycling (CIPR) Equipment

Intermediate Roller

Breakdown Roller

Finish Roller

Cold-in-Place Recycling (CIPR)

Behind Paver

After Compaction

1 Week of Traffic

Cold in Place Recycling (CIPR)

- Advantages:
  - Single Pass Operation
  - Short Cure for Open to Traffic
  - Minor Crown Corrections Possible
  - Works Well in Curb Sections
- Disadvantages:
  - Lowering/Adjusting Castings Required
  - Partial Depth (Reflective Cracking Eventual)
  - Mat Tender During Cure Time

Ingham County Project
2012 Haslett Road, Meridian Township

- 2.25 mi 4 Lane Urban C&G Road Resurfacing; 5 inch CIPR Depth, 2 inch 4E HMA Wearing Course
- 55,000 SYD CIPR @ $8.00/SYD
- Profile Milling Along C&G;
  2,500 CYD RAP Exported to Raby Rd
- Crumb Rubber Modified HMA

Ingham County Project
2012 Haslett Road, Meridian

Ingham County Pr
2012 Haslett Roa
Meridian Townshi

Ingham County Project
2012 Haslett Road, Meridian

Ingham County Project
2013 Haslett Road - Meridian

2012

2015

FULL DEPTH RECLAMATION (FDR)

What is Full Depth Reclamation (FDR)

- Crushed (& Shaped) HMA Base
- Blend Aggregate Base with Pulverized HMA
- 75 – 80% RAP to Aggregate Ratio Preferred
- Add Aggregate to Improve Structure Number (SN)
- Regrade Base
- Base Stabilization (4 to 8 inches) Improves Aggregate SN:
  - Bituminous Stabilization
  - Chemical Stabilization

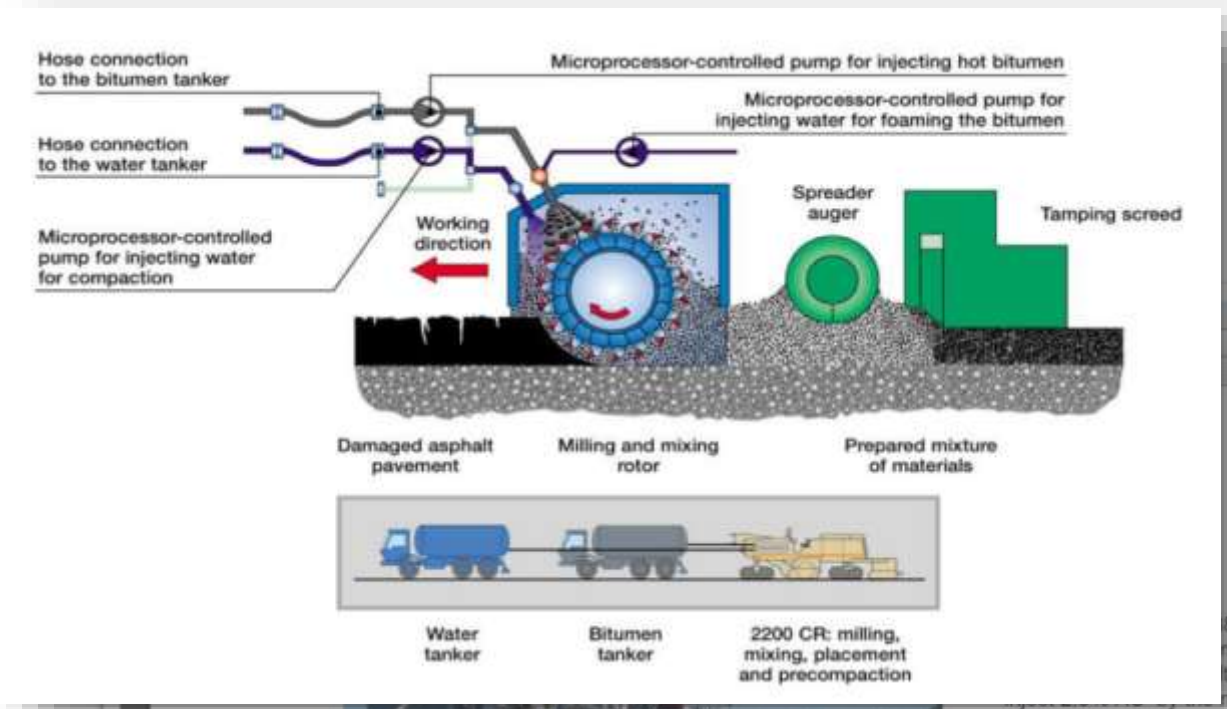
Types of (FDR) Stabilization (Binders)

- Bituminous Base Stabilization:
  - Engineered or Conventional Emulsion
  - Hot Liquid AC
  - Foamed Hot AC
- Chemical Stabilization (Pozzolanic)
  - Cement
  - Lime
  - Type C Fly Ash
  - Kiln Dust

Full Depth Reclamation (**FDR**)

Full Depth Reclamation (FDR)

- Equipment/Processing Variations:
  - Single Pass Equipment (Same as CIPR)
    - Paver Placed
  - Multiple Pass Equipment
    - Single or Multi-Drum Stabilizer
    - Stabilized in Place
    - Graded and Compacted
- Requires Wearing Course (HMA, Chip Seal)



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- Same Equipment as CIPR
  - No Grading
- Separate Paver Can Be Used

Multi-Pass FDR ment

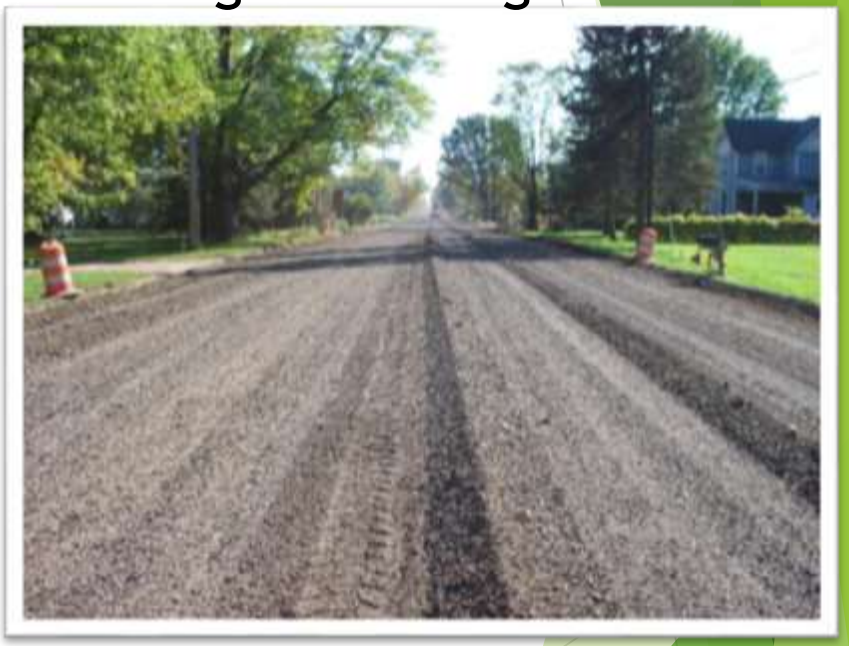
Multi-Drum Unit
(Requires PreCrushing)

Single Drum Unit
(PreCrushing Optional)

Multi-Pass, Multi Drum FDR

PreCrushing

Grading/Balancing



This Method Provides More Uniform Stabilization Depth Where Crown Correction is Required

Multi-Pass FDR
t/Process

Spray Bar – Multi Drum

Compaction

Multi-Pass EDR Process

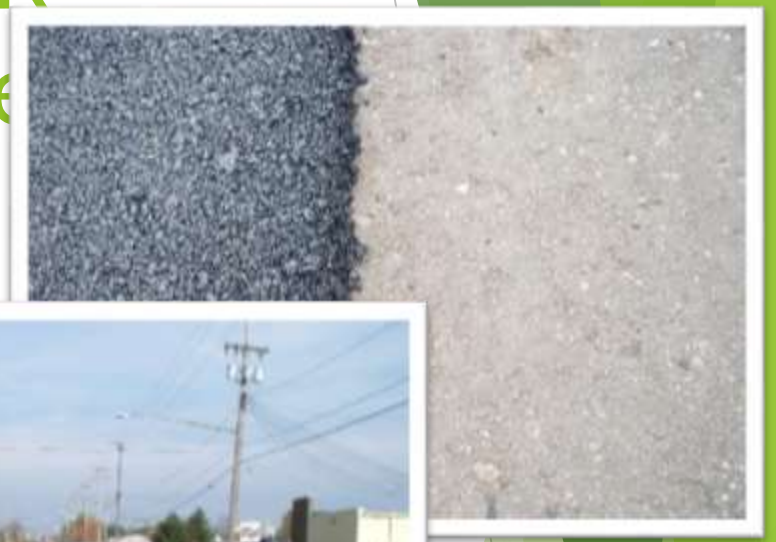
Grading Stabilized Base

Completed Grade

Completed FDR
d Base

Texture

Overla



Full Depth Reclamation (FDR)

- Pavement Deficiency/Distress Corrected with FDR
  - Frequent Deep Transverse and/or Lateral Cracking
  - Heavy Map/D Cracking
  - Reflective Cracking
  - Heavily Patched/Potholed
  - Severe Rutting or Shoving
  - Parabolic Crown
  - Insufficient base strength

Suitable FDR Candidates

Full Depth Reclamation (FDR)

- **FDR Advantages**
  - Cost Effective Compared to Reconstruction $5-7/SYD Depending on Depth, AC Content
  - Reduced Trucking
  - Reduced Construction Time (Short Cure)
  - Allows for Cross Section/Crown Corrections
  - Added Pavement Structure
    - Add RAP or Aggregate
    - Stabilized Base 2.5 x SN Untreated Aggregate
  - Minimal Grade Raise
  - Reflective Cracking eliminated

Full Depth Reclamation (FDR)

- **FDR Disadvantages**
  - Must Lower Structures, Survey Monuments
  - Traffic Disruption > CIPR (Aggregate Surface)
  - Minimal Grade Raise
  - Moisture Sensitive
  - Must Correct Drainage Problems

Not a Good Candidate

ICRD Recent Projects
2009 Williamston Rd

3” HMA, 13A Surface over

6” Engineered Emulsion Stabilized FDR

ICRD Recent Projects
2010 Mt. Hope Rd. Meridian

300 lb/syd HMA LVSP, 6.5” AC FDR

GROUND TIRE (CRUMB) RUBBER MODIFIED HMA PAVEMENTS IN INGHAM COUNTY

Crumb Rubber (CR) Modified HMA - Proven Technologies in U.S.A.

- Terminal Blend – CR & Polymer Blend Mixed at Asphalt Terminal
- Wet Process – CR Mixed at HMA Plant with Specialized Equipment
- Dry Process – CR Blended with RAP Stockpile at HMA Plant
- NOTE: CR Granules Soften, But Do Not Melt in AC Binder or HMA Mixture

CRUMB RUBBER (CR) MODIFIED HMA - EMERGING TECHNOLOGIES

- Pre-Swollen – CR Pretreated/Soaked in Liquid Asphalt Absorbs AC and Expands; Blended with HMA Mixture with RAP Stockpile
- Devulcanized – Emerging Technology to Process CR into Liquid Introduced to AC at HMA Plant, Akin to Liquid Polymer (Rubber Melts)

MDEQ SCRAP TIRE MARKET DEVELOPMENT PROGRAM GRANT

- Up to $500,000 Per Year
- ICRD Partners with Michigan State University to Research/Develop CR Modified Mixtures Suitable for Michigan Climate

CRUMB RUBBER MODIFIED HMA PROJECTS IN INGHAM COUNTY

YEAR	PROJECT	TYPE	GRANT AMOUNT
2011	WAVERLY RD	TERMINAL BLEND	$ 287,400.00
2012	HASLETT RD	WET PROCESS	$ 151,100.00
2013	CORNELL RD	TB/DRY HYBRID	$ 192,000.00
2014	BENNETT RD	TB/HIGH RAP	$ 178,200.00
2014	KINAWA RD	TB/HIGH RAP	$ 189,900.00
2014	HAGADORN RD	TB/HIGH RAP	$ 38,500.00
2015	LAKE LANSING RD	PRE-SWOLLEN	$ 300,000.00
2016	?OKEMOS/JOLLY RDS	DEVULCANIZED	$ 300,000.00
	Total MDEQ Grant Funding		**$1,637,100.00**

2013 Cornell Road Meridian Twp

CR MIX / CONTROL MIX
HYBRID DRY/TERMINAL BLEND

2014 Bennett Road, Meridian Twp

- 1.5 mi 2 Lane w/ Paved Shoulders; Full Depth Cold Milling, Aggregate Base Conditioning, Intersection Widening, and Repaving
- 2,700 CYD RAP Delivered to 2 Locations
- High RAP Content Crumb Rubber Modified HMA

2014 Bennett Roac
Meridian Twp

CR Mix / Control Mix

Control Mix / CR Mix

2014 Kinawa Road, Meridian Twp.

- 1.05 mi 3 Lane Curb & Gutter;
- 21,000 SYD Cold Milling
- 1,500 CYD RAP Delivered to Unpaved Local Road
- 22,000 SYD HIPR @ $ 4.02/SYD
- +1,100 CYD Subgrade Undercutting, Type I (RAP Backfill)
- High RAP Content Crumb Rubber Modified HMA

2014 Kinawa Road Meridian Twp

CR Mix / Control Mix

SUMMARY

Ingham County Has Realized Significant Cost Savings and Extended Project Budgets with the Successful, Aggressive Use of Multiple Recycling Methods, Combined and Coordinated among Multiple Concurrent Projects

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