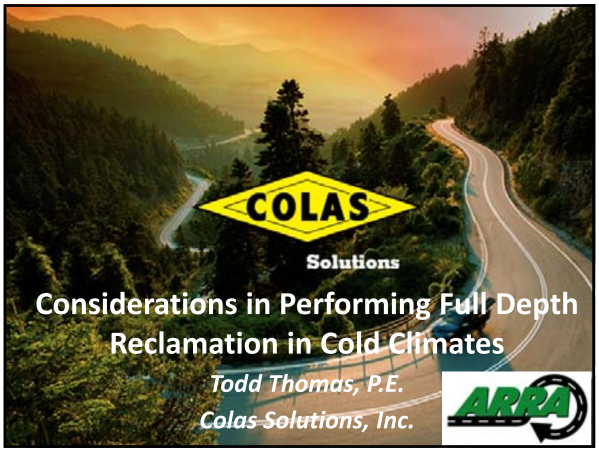
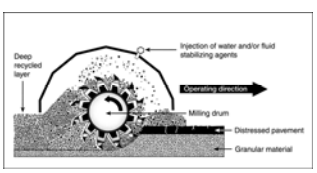


Outline

1. Full depth reclamation (FDR)
2. Role of pavement in cold climates
3. Project selection guidelines
4. Mix design considerations
5. Construction considerations
6. Performance
7. Environmental and cost advantages
8. Summary and conclusions

Definitions

- FDR – full depth reclamation construction process
- RAP – reclaimed asphalt pavement, created from the reclaimer grinding the asphalt pavement
- EATB – emulsified asphalt treated base, created when asphalt emulsion is mixed by the reclaimer with the reclaimed materials



Full Depth Reclamation

Full Depth Reclamation (FDR) is a pavement rehabilitation technique in which the full flexible pavement section and a predetermined portion of the underlying materials are uniformly pulverized and blended together to produce a homogeneous stabilized base course.

Common additives:

- Asphalt emulsion
- Foamed asphalt
- Cement or fly ash

This presentation focuses on FDR with asphalt emulsion – asphalt emulsion treated base

Why Recycle

Correct pavement defects

Increase structural capacity

Geometry – Limited elevation rise or limited width

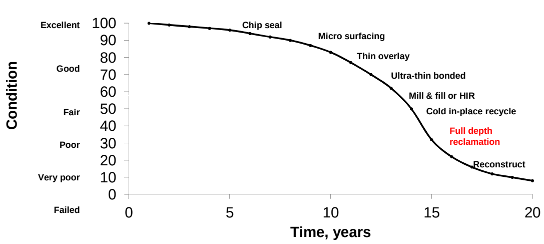
Reuse valuable resources

Economics

Reduce environmental impact

Typical Pavement Deterioration

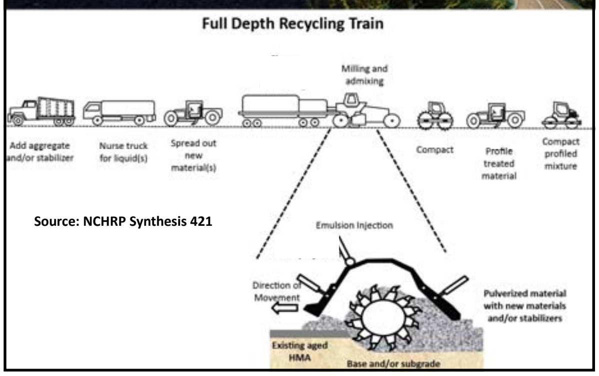
and preservation or treatment method



Full Depth Reclamation

- Spread add-stone in front of reclaimer, if any
- Pre-pulverize the bituminous surface at the specified depth (4”-8”) while adjusting moisture content
- Shape pulverized material to proper grade and cross slope
- Compact lightly to avoid moisture loss / carry traffic for short time
- Spread dry additive if needed
- Perform mixing pass at specified depth while simultaneously mixing water and/or emulsion and mixing
- Roll with padfoot roller and remove pad marks with grader
  - Padfoot roller sometimes not needed with 4” to 6” thickness
- Shape with grader
- Final compaction – creates emulsified asphalt treated base

Full Depth Reclamation



Source: NCHRP Synthesis 421

Role of Pavement in Cold Climates

- Distribute loads from heavy traffic
- Effective pavement design
  - Protect frost-susceptible soil to prevent frost-heave
    - Effective side drainage or internal drainage
    - Sufficient thickness above frost-susceptible soil
- Reduce effects from environmental-related damage
  - Differential frost heave movement
  - Spring-thaw weakening

Role of EATB in Cold Climates

- Reduces water infiltration
  - Replace air with asphalt in the granular base
- Reduces moisture susceptibility of granular base courses, thereby having better resistance to frost heave and spring-thaw weakening
  - Coat fines and reduce or eliminate water penetration
- Thicker bituminous structure moderates the freeze-thaw cycling effects in the pavement
- -> Reduce water penetration / reduce moisture susceptibility / create thicker layer

Project Selection Considerations

- Curbed streets, highways, county roads. Paved or gravel roads.
- Typical blends
  - Can be 0% RAP to ~90%
- Asphalt thickness
  - Reclaiming thickness usually 4 - 8 inches
  - Reclaimer must go under asphalt layer

Project Selection Considerations

- Aggregate base thickness
  - Enough to stay out of subgrade
  - Some subgrades may be suitable (sand, gravel)
  - Stay out of clay or material with large stones
- Drainage
  - Well draining structures for curing and long-term durability is important
  - Proper depth shoulders for GWT
- If widening, ensure uniformity of materials across the pavement width due to differential frost heave

Mix Design Considerations

Material evaluation

- No. 200 on the RAP/aggregate blend typically < 20% for optimum performance
- Cleanliness of fines
  - SE typically > 30 for optimum performance
  - Alternatively, PI < 6
- Use cement or lime if P200 is high or SE is low
  - Usually 1 to 1.5%
- Design emulsion content typically 3 to 6%
  - 65% residue
  - Lower emulsion content for higher percentage of RAP

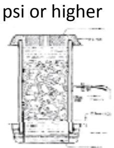
Mix Design

- Superpave gyratory compaction or Marshall compaction – 30 gyrations or 50-blow Marshall hammer

- Early strength
  - For estimating ability to open to traffic after finish rolling
  - For understanding emulsion curing characteristics
  - Understand effects of additional lime or cement
  - Testing time and temperature for local conditions
  - Tests – Marshall stability or cohesiometer

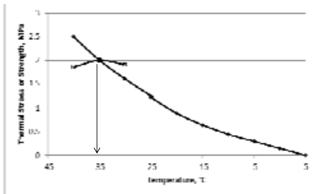
Mix Design Considerations

- Moisture susceptibility
  - Tensile strength ratio (AASHTO T-283), with or without freezing. Affected by emulsion content, presence and amount of dry additive, and P200 quantity / quality
  - Tube suction (Tx 117E). Sensitivity to moisture due to capillary action.
  - Improved with cement or lime
- Resilient modulus at 25°C – 150,000 psi or higher



Mix Design Considerations

- Thermal cracking
  - AASHTO T-322, Determining the Creep Compliance and Strength of Hot-Mix Asphalt (HMA) Using the Indirect Tensile Test Device
  - AETB mixtures can be designed to have good cold-temperature performance
  - Predicted low temperature of pavement in Anchorage area:
    - -30℃ at surface
    - -27℃ at 3 inches depth



Construction Considerations

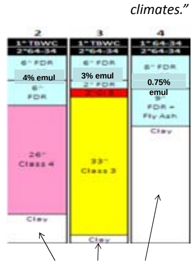
- Construction temperature 40°F and rising
- At least 7 days before freezing temperatures (though hard to predict)
- Traffic allowed on EATB after finish rolling, assuming properly designed and constructed project
  - May need to limit heavy trucks
- Typically 3 to 10 days before overlay or seal is applied
  - Consider a fog seal until overlay is placed to protect from rain and traffic
  - Minimum double chip seal
- Cement or lime aids in cure time

Performance - Example

MnRoad – "Improving the way we construct and maintain our highways in cold weather climates."

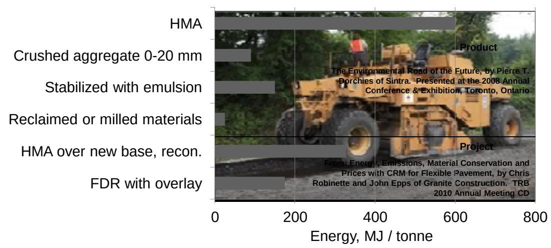
MnRoad high-volume road: I-94 WB

- Predicted low temperature of pavement:
  - -32°C at the surface
  - -28°C at 3 inches depth
  - All three mixes exceeded requirements
- 27" annual precipitation
- 6" or 8" EATB overlaid with 3" HMA
- 3,500,000 ESALs – designed for 5 years
- Opened February 2009 – 60% of design traffic (2.2M ESALs to April '11)
- Performing well - No transverse cracking or performance issues



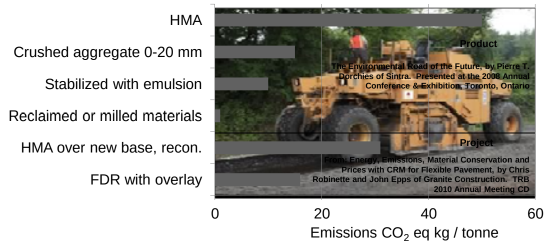
Energy Consumption

For the materials, manufacturing, hauling, and placement



GHG Emissions CO_2 eq.

For the materials, manufacturing, hauling, and placement



Economics of FDR

- Initial cost savings of 25% to 33% or higher compared to the cost of reconstruction have been realized
- Case Study – 0.8 mile city street with 4 to 5 lanes
  - 3000 fewer loads of materials were trucked on and off the project
  - Construction time was reduced from 120 days to 40 days

Summary & Conclusions

- In-place recycling is a cost-effective treatment for improving pavement condition
- EATB reduces water infiltration in the pavement structure and reduces moisture susceptibility of granular bases
- EATB, when properly designed and constructed, is resistant to moisture damage and thermal cracking
- Use lime or cement to aid in curing and moisture susceptibility
- Proven cold temperature performance
- FDR is a lower energy and lower GHG option compared to reconstruction
- EATB behaves like a lower stiffness HMA layer

Summary & Conclusions

For more information on FDR and in-place pavement recycling and soil stabilization:

www.arra.org