MnDOT Reclamation Inspector's Guide
Full Depth Reclamation and Stabilized Full Depth Reclamation
2/2/2016

Forward

Reclamation utilizes large quantities of in-place materials. The quality and placement of these materials involves the application of various test procedures and inspection techniques to ensure that they are placed within the specification requirements.

This manual helps to ensure that uniformity of process is followed.

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Index

This Inspector's guide is broken down into five sections:

- Reclamation Basics
- Preliminary Responsibilities
- Project Inspection Responsibilities
- Common Problems and Solutions
- Summary: The nine most important aspects to have a successful reclamation project.

A) Reclamation Basics

The reclamation process reuse existing road materials and significantly reduces the use of fossil fuels and virgin resources such as aggregate and asphalt.

Reclamation consists of pulverizing and mixing in-place asphalt materials with or without underlying base and with or without the addition of stabilizing agents such as asphalt, additional aggregate, cement or compaction aids. The material is then typically overlaid with a new asphalt pavement.

The two types of reclamation currently employed by MnDOT are:

- Full Depth Reclamation (FDR): where in-place bituminous is ground with in-place base, with or without the placement of additional aggregate on top of the bituminous pavement before reclaiming.
- Stabilized Full Depth Reclamation (SFDR): where on the first pass in-place bituminous is ground with in-place base, with or without the placement of additional aggregate on top of the bituminous pavement before reclaiming. Then there is a second pass where liquid asphalt and sometimes cement is incorporated.

Inspection guidelines for Cold In-Place Recycling (CIR) are included in a separate document. CIR is a process where in-place bituminous pavement is reclaimed and new asphalt binder or emulsion is added in a single pass.

B) Preliminary Responsibilities

1) Document Review

- Project Specifications
- Mix Design
- Structural Pavement Design

- Construction Manual
- Traffic Control Plan
- Owner/Agency Requirements
- Stabilizing Agent Manufacturers' Instructions
- Safety Data Sheets (SDSs)
- Health and Safety Plan and Job Hazard Analysis
- Schedule of Materials Control

2) Note In-Place Pavement Distresses that may indicate weak subgrade that needs to be repaired

Much of the following should be performed in the scoping stage of design, and may already be identified in the plan for remediation. However the inspector should also examine the project area, as they may find additional deficient areas that need to be addressed.

- Note the types and causes of existing pavement distresses. See MnDOT Distress Identification Manual.
- Identify areas of excessive surface deformation which may indicate soft subgrade conditions or drainage deficiencies. To correct subgrade problems the reclaimed material typically is moved to one side or completely removed, then the subgrade is either:
  - dried and re-compacted,
  - stabilized with cement or
  - a geotextile fabric is placed as a separation layer.
- Poor drainage conditions can be addressed by eliminating the source of water by installing surface and/or subsurface drains to direct the water away from the roadway. The reclaimed material is then placed back on the prepared subgrade and compacted.
- Review core and Ground Penetrating Radar (GPR) data from both the center and edge of the pavement, to confirm the thickness of materials to be reclaimed for both the bituminous and base. Verify that existing structures, e.g. guardrails, curbs and bridge clearances, do not impose limitations on FDR operations or final pavement geometry.
- Determine whether paving fabric or other geotextile materials or coal tar are present within any of the layers to be reclaimed, because fabric and geotextiles will not get processed well during reclamation. For SFDR, old coal tar bituminous does not mix well with new emulsions or new bituminous foamed materials, and you will end up with lower anticipated SFDR strength.
- Note the presence of utility covers (manholes and valves), their location, frequency and elevation and coordinate with utility owners and the Contractor a plan to address affected areas without disturbing utilities.
- Consider the impact of other issues such as patched areas and reclaiming shoulders, as they will usually have a different depth of bituminous and aggregate, and different bituminous composition.

- Contact maintenance personnel to get their input regarding routine and extraordinary maintenance for the project site, and also review road history reports.

3) Materials Checks

- Obtain a sufficient number of cores/samples (minimum one every half mile) for mix design development and to ascertain consistency of in-place bituminous thickness and condition.
- Samples are evaluated for consistency over the length of the project.
- The stabilizing agents may include:
  - Aggregate for mechanical stabilization
  - Emulsified asphalt or foamed asphalt for stabilization
  - Cement for Chemical Stabilization

4) Preconstruction Meeting

- Ensure that all necessary contractor and agency personnel attend the preconstruction meeting.

5) Surface Evaluation

- Identify areas in the Plan where the subgrade is to be repaired.
- Identify additional areas not in the Plan where the subgrade may need to be repaired.
- Review required pre-milling depths to ensure that there is adequate bituminous, aggregate and crushing in the final product. If you are considering milling to a prescribed depth to meet a profile, but milling would remove too much of the aggregate and crushed fines, consider instead removing material after pulverization. This excess material may then be used for other shoulders or gravel surfaced roads within your system. Ensure that pre-milling is performed satisfactorily.

6) Equipment Inspections - *Review 2215.3 and special provisions for equipment requirements.*

a) Reclaimer

- Verify that the cutting drum is the correct width.
- Verify that the reclaimer has sufficient weight and horsepower to cut to the depth and tolerances specified within the contract documents.
- Verify that the carbide cutting teeth are all in place and in adequate condition.
- SFDR: Verify that the spray bar and nozzles are working properly and not clogged.
- SFDR: Verify that the on-board stabilizing agent system is equipped with a meter capable of recording the rate of flow and total amount of each liquid being added to the reclaimed material.
- SFDR: Verify that the reclaimer is equipped with an on-board foam generating system including a foamed asphalt sampling valve when foamed asphalt is being used as the stabilizing agent.
- SFDR: Verify that the on-board stabilizing agent system has a positive interlock system linked to the forward speed of the reclaimer so that the amount of liquid stabilizing agent

being added will change according to the operational speed of the reclaimer.

- Verify that the correct amount of water is being added to achieve a homogenous mixture and achieve specified percent compaction. SFDR: The total in-place moisture, plus any additional moisture plus the bitumen added should be at or below the optimum moisture content of the mix design.

b) Spreader

- SFDR: If required, verify that the spreader is properly calibrated and is capable of accurately dispensing the required quantity of stabilizing agent and/or additive.

c) Motor Graders

- Verify that the motor graders used are in accordance with those specified in the contract documents.

d) Rollers and Scrapers

- Verify that working scrapers are in place on all rollers as required by the contract documents.

e) Other Equipment

- Haul trucks
- Front End Loader
- Water Truck

7) SFDR: Weather Requirements

- Verify that the ambient air temperature (in the shade) meets contract specification requirements, typically a minimum of 50°F and rising when using bituminous products and not foggy. Consider that variations in temperature, humidity, and wind conditions will all affect breaking and curing times. There can be no anticipated freezing temperatures within 48 hours after stabilization, see 2215.3.C.
- Verify that no significant precipitation (or fog for bituminous stabilization) is predicted during construction operations, in accordance with contract specifications.

8) Mix Design

- Review the mix design requirements.

9) Traffic Control

- Verify that the traffic control plan complies with the contract documents and the Manual on Uniform Traffic Control Devices.
- Verify that the signs and devices erected on the roadway match the traffic control plan contained in the contract documents.
- SFDR: Ensure that flaggers do not hold stopped traffic on freshly treated material.
- Ensure that signs are removed or covered when they no longer apply.
- Ensure that an appropriate action plan is developed and implemented for emergency vehicles passing through the project.

- Ensure that any unsafe conditions are reported to a supervisor.

C) Project Inspection Responsibilities

1) Testing required during the project (See Schedule of Materials Control)

The testing required for FDR includes:

- Gradation
- Compaction (DCP)
- Moisture Content during Compaction
- Depth Check
- Test Rolling

The testing required for SFDR includes:

- Gradation: top size and full gradation
- Compaction (DCP) for unstabilized portion
- Moisture Content during compaction of unstabilized portion
- Depth Check
- Moisture content before injection with bituminous
- Yield checks on asphalt
- Control strip, for compaction
- Compaction compliance using nuclear density gauge
- Bituminous samples
- Calibration of cement application rate, if applicable
- Foaming checks, if applicable

2) Pulverization

- Verify that the depth of pulverization and during the injection stage meets the Contract; however beware of pulverization that is too deep, especially for sections with no granular subbase. If pulverization goes through the base and into a plastic subgrade, it will contaminate the material with subgrade fines. Also, the process requires a strong platform to compact against; therefore to minimize risk, it is best to leave at least three to four inches of base, unless there is a granular subbase.
- Verify that the pulverized material meets the top size gradation per the specification. Direct the Contractor to remediate areas where the top size is too large. Pay close attention to areas which are highly alligator cracked as these areas will not tend to meet gradation. Oversize material tends to get buried, therefore observe when the motor grader makes its initial pass to see if over-size material is exposed.
- The Contractor can modify his process to lower the occurrence of oversize material by using several methods including:

- Slowing the speed of reclaiming
- Adjusting the breaker bar within the reclaimer (check gap between drum and breaker bar)
- Making a second reclaiming pass
- Manually picking out over-sized material

- SFDR: Review the full gradation and compare it to the gradation used in the mix design to see if it is finer or coarser. Finer ground material may need more bitumen and coarser less. Confer with the Contractor for possible application rate modifications. Additional, small areas within a project may need variations in the mix design, again confer with the Contractor for possible application rate modifications.

3) SFDR: Mixing and Placement

- SFDR: Verify the moisture content of the pulverized material before injection to determine if an adjustment is needed to reach or maintain optimum moisture.
- Verify that the blending/mixing of water (if needed) and stabilizing agent is adequate to ensure a homogenous, consistent blend throughout the treatment section.
- Monitor the amount of water introduced to maintain the specified range of optimum moisture content.

4) SFDR: Field Observations & Tests to Evaluate Consistency & Design Application Rate

The consistency in the color of the material immediately behind the recycler will usually indicate whether or not the machine is set up properly.

A gradual change in color across the width normally indicates that one end of the drum is lower than the other.

A lighter appearance indicates dilution (under-application of water and bitumen stabilizing agent) caused by the drum not penetrating too deep into the pavement.

A darker color indicates an over-application due to the drum not penetrating to the required depth.

A lighter appearance of material throughout the full application width may also indicate a finer gradation, which may need additional asphalt.

5) SFDR: Tire Test

Bitumen treated material should not adhere to the rear wheels of the recycler.

The left picture shows what should be seen behind the recycler. The right picture shows material sticking to the rear wheels may indicate that the treated material is poorly mixed. This operation should be stopped immediately to determine the cause. Poorly mixed material will also stick to the drum of the roller, causing material build-up and further problems. Sticking material may also be cause by too high an application of bitumen because of a coarser gradation. Additionally, in very hot weather sticking may also occur, and a slight increase in water may alleviate the sticking.

Minimal material sticking to the wheels of the recycler

Material sticking to the wheels of the recycler

Observe Tires Behind the Reclaimer (TG 2 – Bitumen Stabilized Materials)

6) SFDR: Ball Test

This test requires a round specimen the size of a fist to be made from a sample of material picked up from behind the recycler and firmly squeezed between both hands. Balls made with Foamed AC can be tested right away, but balls made with emulsion should be left in the sun and allowed to dry for at least 30 minutes so that the bitumen emulsion can break (color change from brown to black). Once a ball has been formed, the following visual observations can be made: The "test" consists of holding the ball between the thumb and index finger and gently applying pressure on opposite sides of the ball to gauge the cohesiveness of the material. The ball should deform before falling apart. Inspect the face of the broken ball too see how well the bitumen has dispersed. If no bitumen can be seen, the mix is perfect. The more bitumen blobs or stringers there are that can be observed, the worse the quality of the mix. Clean all loose material from the palms of the hands and observe the bitumen spots. The warmth of the hands and pressure applied will permit the bitumen to stick. Lots of tiny spots indicate good dispersion whilst larger "blobs" are the stringers resulting from poor dispersion. If a ball cannot be formed or does not deform before breaking, then the mix may be too lean.

7) Stabilizing Agent and Stabilizing Additive Spreading

- SFDR: Verify that application rates of stabilizing agents and additives are meeting the application rates specified in the mix design and remain consistent throughout the treatment area.
- SFDR: Check that application rates on the reclaimer's flow meter (bituminous binder) are accurate.
- SFDR: Check that the calibration on the spreader equipment for cement is correct.
- Check that the calibration on the spreader equipment for additional rock is correct.

8) SFDR: Stabilizing Agent Mixing and Depth

- If cement is used, ensure that the mixing begins within 30 minutes of cement placement, as hydration of cement may occur and strong wind can disperse the cement.
- During injection, check the depth of injection and visually observe that the new asphalt is being uniformly blended into stabilized material. If the material is not uniformly blended, or the depth is not as per the Plan, require the Contractor to remix the non-compliant areas. Check the first 200 feet each day to insure that the reclaimer is performing correctly.

9) SFDR: Compaction, see 2215.3.C.7, 2215.3.C.8 and 2215.3.C.8.a

- Verify that an adequate rolling pattern has been established and that the compaction roller is

immediately following the reclaimer.

- Breakdown rolling should be with a padfoot roller. Rolling should continue until the roller "walks out" of the material.
- Monitor that density/compaction of the mat meets specification/contract document requirements. For the injection pass a control strip is required.

10) SFDR: Grading

- Monitor to ensure the motor grader is closely (500-1000 feet maximum) following the compaction rollers.
- Be careful to not overwork the treated mat as to compromise its structural integrity during the curing process.
- Ensure that the material is kept within the roadway width.
- Monitor surface moisture content and apply water as necessary to maintain optimum moisture.
- Check profile.
- Check cross-slope.
- Make sure the centerline is formed.

11) SFDR: Finish Rolling

- It is preferred to roll the mat in static mode to reduce the opportunity for micro-cracking of the FDR surface.

12) SFDR: Initial Opening to Traffic

- Ensure that the material in the recently completed mat meets the contract requirements for compaction density.
- Proof roll the surface prior to opening to initial traffic to verify material can support light traffic.
- Ensure that temporary pavement markings, if required by the contract documents are in place prior to opening the surface to traffic.
- Ensure initial traffic does not impair material curing.

13) Seal

Apply a fog seal to the top surface, using the rate and type and at the time as required of the Contract.

14) SFDR: Bituminous Placement

Place and compact new asphalt pavement no sooner than three calendar days after injection and compacted at any location, and when the surface does not deflect under construction equipment and meets quality compaction per 2105.3.F.2. The SFDR will continue to gain strength as it cures out.

D) Common Problems and Solutions

- Pulverized material is not consistent with the material samples used in mix design:
  - Determine if the current mix design is still applicable. Consider adding additional rock for FDR, if compaction targets are not being met.
  - SFDR: Determine if a new stabilizing agent application rates will be better suited based on the gradation of material on the project.
- SFDR: The pulverized material is not at target moisture content:
  - Add water to reach target moisture content before or during treatment.
  - Dry the pulverized material by aeration before treatment.
  - Final target moisture is the optimum moisture from the mix design and equals the in-place moisture plus any additional moisture added during stabilization plus the added bituminous emulsion or foam.
- The material is soft or deforms excessively
  - Aerate, reshape and compact if instability is due to excessive moisture.
  - Replace with suitable materials.
- The subgrade is failing below the proposed section:
  - Remove the pre-pulverized material and repair the subgrade.
- Pre-milling depth
  - Mill and remove enough material to account for the volume gain acquired by the pulverization process and addition of a stabilizing agent (typically 10% of the original volume); this is particularly important on projects that are locked in by grade.

E) Summary: The nine most important aspects to have a successful reclamation project are:

1) Use the required equipment for compaction, and do not allow the Contractor to start reclaiming until all required equipment and operators are mobilized on the project.
2) Assess if a field change is required either by requiring additional crushed rock, a modification of the mix design rates for SFDR, or repairing the subgrade.
3) Monitor the reclaim depth and modify if necessary. If you do not have a granular subbase or subgrade, leave a minimum of 3-4 inches of base for FDR. For SFDR reclaim only an inch or two into the base as the deeper you go the amount of oil demand increases. Also for both FDR and SFDR the deeper you reclaim the less solid substrate you will have to compact against. Use depth checks to monitor this.

   Additionally, if Pit Run material is under the bituminous and contains rocks larger than 3", raise the reclaimer's cutting head.
4) Review core and GPR (ground penetrating radar) data for depth changes of the bituminous and base. Mark road sections where depth of bituminous changes. Take extra depth checks in transition areas.

As an illustration the two cores below were sampled from the same project in the design stage.

If the design called for milling the top four inches and reclaiming the next six inches, then in the area of the core on the left there would still be a good amount of rock in the final product and most likely (you should also check the in-place base gradation and depth) there would be base to compact against.

For the core on the right, this would not be the case. Therefore, for that area, consider only milling two inches and reclaim to a depth leaving 3-4 inches of base in-place. If you do decide to mill shallower in this area, you will either have to plan for a slight grade raise, or have the Contractor remove the excess material.

5) Use the correct amount for water to compact FDR (3-7%) and SFDR (final total moisture should be at the optimum moisture content from the mix design (includes the in-place moisture plus any additional moisture added during stabilization plus the added bituminous emulsion or foam).
6) Monitor the top size gradation
7) SFDR: Monitor the entire gradation, and compare to the mix design, consult with the Contractor if a change in the mix design is warranted.
8) Check for compaction compliance
9) SFDR: When the foaming asphalt method is used for SFDR, keep away from the supply truck, as the oil is in excess of 300^0 F. Monitor the contractor for the required foaming checks.

Sources

- MnDOT Specifications 2215 & 3135, special Provisions & MnDOT Grading & Base Manual
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- MnDOT Distress Identification Manual. February 2011