

1 Supplemental Specification 3.4, Full Depth Reclamation

**3.4 FULL DEPTH RECLAMATION**

3.4.1. GENERAL

3.4.1.1. **Description**

Full Depth Reclamation (FDR) is a pavement rehabilitation technique in which the existing asphalt pavement and a portion of the underlying granular base is pulverized; shaped and compacted; re-processed and stabilized with an asphalt product and, if required, other additives or additional granular materials; shaped and compacted to specified dimensions. After curing, an asphalt tack coat and asphalt concrete mixture or other type of surfacing treatment is placed as specified.

3.4.2. DEFINITIONS

**Foamed Asphalt** A process where heated asphalt cement is expanded from its normal volume by the addition of precise amounts of water.

**Control Strip** A section of stabilized FDR constructed using the equipment and method of compaction as prescribed herein.

**Control Density** The maximum wet density attained on a "Control Strip".

**Lot** Normally defined as the quantity of stabilized FDR material processed in one day's production with no changes to the approved mix design. A days production of less than 4 hours may be combined with the previous or following days production at the Consultant's option. If the Consultant suspects a portion of a Lot is substandard, he may order extra testing to define the area and severity of the deficiency. A new Lot will be designated for this portion if this extra testing indicates the FDR material is subject to rejection.

**Visually Failed Area** An area of the FDR mat which fails, loses specified density, becomes too wet, ravels, contains excess asphalt stabilizer or oil spills, becomes rutted, distorted, loose or rough, or contains any other defect judged by the Consultant to negatively affect the long term performance of the pavement structure.

3.4.3. MATERIALS

All materials necessary for full depth reclamation described herein, shall be supplied by the Contractor.

3.4.3.1. **Additive Aggregates**

Additional aggregate added to the reclaimed pavement materials shall meet the requirements for either a Designation 2 Class 25 or Class 20 aggregate; or as recommended in the mix design submission.

If applicable, requirements for the maximum percent passing the 80 mm sieve may be waived in order to meet the minimum percent passing for free fines in the combined reclaimed material. The Contractor shall produce crushed aggregate in accordance with Standard Specification 3.2, Aggregate Production and Stockpiling. When required, the Contractor shall supply aggregate

in accordance with Standard Specification 5.2, Supply of Aggregate, and haul materials in accordance with Standard Specification 4.5, Hauling.

Additive aggregate used in order to improve the mix design properties of the stabilized FDR material and not specified to be added in the Special Provisions or shown on the Drawings, shall be used at the Contractor's option and expense.

#### 3.4.3.2. **Water**

The Contractor shall supply and haul all water required for the construction and maintenance of this work.

The water shall be clean and free from deleterious concentrations of acids, alkalis, salts or other organic or chemical substances.

#### 3.4.3.3. **Asphalt Stabilizing Agent**

The Contractor shall supply asphalt products in accordance with Standard Specification 5.7, Supply of Asphalt.

Unless otherwise specified, the Contractor has the option of using either foamed asphalt or an asphalt emulsion as a asphalt stabilizing agent, but not both.

When using the foamed asphalt process, the Contractor shall choose the grade of asphalt cement which displays the best foaming characteristics.

When using an asphalt emulsion, the Contractor may choose which grade of emulsion to use. Use of alternative grades not listed in Standard Specification 5.7 will be allowed, subject to approval by the Consultant. When proposing to use an alternative grade, the Contractor shall indicate the appropriate ASTM or AASHTO material specification.

The type and grade of liquid asphalt for tack coat shall be in accordance with Section 3.19.2, Materials, of Standard Specification 3.19, Prime, tack and Fog Coats, unless otherwise specified.

Sampling of the asphalt stabilizing agent shall be as described in Standard Specification 5.7, and shall occur at a frequency of one sample per three Lots.

#### 3.4.3.4. **Portland Cement**

The Contractor shall use Portland cement as a chemical stabilizing agent at an additive rate of 1.0% to 1.5% by weight of dry reclaimed material and additive aggregate. Additional Portland cement may be used for reprocessing visually failed areas subject to approval by the Consultant.

Other chemical stabilizing agents may be used subject to approval by the Consultant.

#### 3.4.3.5. **Interim Lane Markings**

The Contractor shall apply interim lane markings on the newly constructed FDR surface or tacked FDR surfaces that are to be exposed to traffic overnight.

Interim lane markings shall meet the requirements of Section 3.50.5.8, Interim Lane Markings, of Standard Specification 3.50, Asphalt Concrete Pavement - EPS,.

#### 3.4.4. MIX DESIGN

#### 3.4.4.1. Responsibility for Mix Design

Preparation and submission of FDR mix designs for Consultant verification and approval is the responsibility of the Contractor. The design shall be prepared by a laboratory that is pre-qualified by the Department in the category of Mix Design - Marshall, or can provide proof of experience in preparing FDR mix designs.

The mix design shall be submitted to the Consultant a minimum of seven days prior to the start of any stabilization operations.

All costs incurred in mix design formulation are the responsibility of the Contractor.

#### 3.4.4.2. Requirements for Mix Design

For mix design purposes, and prior to commencing the Work, the Contractor shall obtain representative samples of the material that will be produced during the reclaiming operation. These samples shall be used along with any additive aggregate and Portland cement, to establish the design rate of asphalt stabilizer as a percentage by mass of reclaimed asphalt pavement and additive aggregate.

The FDR mix design shall follow the procedures outline in the Wirtgen Cold Recycling Manual (Wirtgen GmbH, Windhagen, Germany, 2nd Edition, Appendix 2 - Mix Design Procedures).

The FDR mix design at the Design Asphalt Content and Optimum Total Fluid Content shall meet the requirements outlined in Table 3.4.3.2, Full Depth Reclamation Design Criteria. The Design Asphalt Content shall be chosen to optimize the performance characteristics of the FDR and not solely to meet minimum design criteria.

**Table 3.4.3.2 Full Depth Reclamation Design Criteria (Emulsion or Foamed Asphalt)**

PROPERTY	DESIGN CRITERIA
Air Voids (%)	Report Only
Dry Tensile Strength (kPa) @ 25°C	250
Tensile Strength Ratio (%)	50

For materials stabilized using the foamed asphalt process, the minimum amount of free fines, or fines that are not bound within the reclaimed asphalt pavement, shall be 5% or greater passing the 80 mm sieve.

The percent by mass of asphalt stabilizing agent to be added to the unstabilized material shall be a minimum of 2.0%.

In addition to reporting the above listed criteria the mix design submission shall include:

- i) Information on the type, manufacturer and supplier of the asphalt stabilizer.
- ii) The asphalt content and aggregate gradation of the asphalt concrete being incorporated in the FDR process.
- iii) The design percentage and gradation of additive aggregate.
- iv) The design addition rate of asphalt stabilizer and foaming characteristics if the foamed asphalt process is used.
- v) Percent of free fines passing the 80 mm sieve if the foamed asphalt process is used.

- vi) Design addition rate for Portland cement.
- vii) The percentage moisture content to obtain the Optimum Fluids Content.
- viii) All calculations performed to determine the Optimum Fluids Content and design application rate for the asphalt stabilizer.
- ix) Bulk and maximum theoretical densities at various application rates of the asphalt stabilizer.

A separate and complete mix design will be required for any significant changes to the composition of the existing pavement structure or materials.

The Contractor shall not produce any stabilized FDR mixture prior to receiving the Consultant's written notice that the mix design has been verified. Any stabilized FDR mix produced prior to receiving such notice will not be accepted.

### 3.4.5. EQUIPMENT

#### 3.4.5.1. **Additive Aggregate**

Additive aggregate, if required, shall be uniformly distributed in front of the recycling train.

#### 3.4.5.2. **Recycling Equipment**

The equipment used shall be specially designed for performing FDR, including the ability to uniformly incorporate significant quantities of additive aggregate; and the ability to add an accurate and uniform application of water and an asphalt stabilizing agent.

As a minimum, the milling machine shall have the following features:

- The capacity of milling to a minimum depth of 300 mm in a single pass; and be equipped with an automated sensor system to accurately maintain a preset depth of cut.
- A milling head that rotates upwards into the direction of advance and achieves a minimum 2.0 m width of cut in a single pass.

In order to mix the reclaimed material with aggregate, water and stabilizing agents; the milling, or separate processing unit, shall include the following features:

- A micro-processor control system to regulate the application of water and stabilizing agents in relation to travel speed and mass of material.
- A dual pumping and metering system for applying water and asphalt stabilizing agent simultaneously. The pumping system shall be calibrated to deliver within a tolerance of +/- 3% by volume.
- A system of self-cleaning nozzles that provides uniform application of water and stabilizing agents across the full width of treatment. The application system shall be adjustable for varying widths of treatment.
- When using the foamed asphalt process, an asphalt cement expansion system capable of producing optimum expansion; and an injection system capable of injecting and blending the foamed asphalt uniformly throughout the combined reclaimed and aggregate materials.

### 3.4.5.3 **Straight Edge**

The Contractor shall supply a 3 m metal straight edge for determining conformance to surface tolerance requirements. When requested, the Contractor shall provide the Consultant with the use of the straight edge instrument.

### 3.4.6. CONSTRUCTION

#### 3.4.6.1. **General**

The full depth reclamation operations shall be carried out through a minimum of two separate processing phases. The first or pulverization phase shall consist of milling and mixing the asphalt concrete and base course materials to specified depths such that 100% of the pulverized asphalt material is smaller than 40 mm, and a minimum of 95% of the material is smaller than 25 mm.

The reclaimed material shall be bladed and spread to the width and/or depth shown on the Drawings or as designated by the Consultant. The reclaimed material shall be lightly compacted for traffic accommodation and preparation for further processing.

The application of additive aggregate and stabilizing agent shall be completed in one or more subsequent mixing operations, to the depths and dimensions shown on the Drawings or as designated by the Consultant. In all cases, the full depth of pulverized reclaimed material shall be processed during the subsequent mixing operations. The Contractor shall ensure that none of the underlying grade material is incorporated within the reclaimed material during the mixing operations.

If required, additive aggregate shall be added to the roadway prior to stabilizing. The aggregate delivery vehicle shall have a system for controlled application of the aggregate.

During stabilization operations, the Contractor shall overlap successive passes of the reclaimer-stabilizer by a minimum of 100 mm.

When an emulsion stabilizing agent is used, stabilization operations shall not be carried out when the ambient temperature is less than 10°C, or when the overnight low is forecast to be less than 2°C .

When a foamed asphalt stabilizing agent is used, stabilization operations shall not be carried out when the ambient temperature is less than 5EC.

Stabilization of reclaimed materials shall not proceed during periods of rain or if the surface is in a saturated condition.

The FDR material shall be spread and compacted to the specified width, thickness and cross slope dimensions. The Contractor shall be responsible for managing and disposing of any excess FDR or reclaim pavement materials in a manner subject to the approval of the Consultant. Spreading excess material across existing paved shoulders will not be permitted. No separate or additional payment will be provided to the Contractor for the disposal of excess materials unless otherwise provided in the special provisions.

#### 3.4.6.2. **Density Control**

Compaction of the stabilized FDR material shall be carried out once the material has been spread to the specified widths and thicknesses.

Control over the density to which stabilized FDR is compacted will be exercised by the construction of a Control Strip in accordance with ATT-58 Control Strip Method, with the following modifications:

- References to granular base course shall apply to full depth reclamation.
- The minimum length of the control strip shall be 200 m.
- The maximum allowable thickness for the stabilized FDR material shall be 250 mm.
- The nuclear density readings shall not be adjusted for moisture content.
- Prior to compaction, the moisture content of the stabilized FDR material shall be adjusted to within a range of 0.5% over optimum to 2.0% below the optimum moisture content.
- Minimum compaction equipment for determination of Control Maximum Wet Density shall be two - 12 tonne pad foot rollers, one - 10 tonne vibratory roller, and one - self propelled pneumatic tire roller

The Control Density determined on the control strip shall be the reference compaction standard for acceptance of all remaining FDR material. A new control strip and Control Density shall be determined for any new mix designs; for significant change to the reclaimed materials or processing depths; and any time when directed by the Consultant.

Once the control density has been established, the Contractor may choose his own combination of compaction equipment.

All stabilized FDR shall be tested for compaction using the Test Section Density procedure as outlined in ATT 58.

#### **3.4.6.3. Adjustments to the Mix Design**

The Lot Mean for Dry Tensile Strength and Tensile Strength Ratio shall meet minimum design criteria.

Adjustments to the mix design or to the FDR processing techniques in order to meet tensile strength requirements, compliance requirements and/or to address minor changes to the composition of the existing pavement structure or materials shall be taken by the Contractor subject to the approval by the Consultant. Prior to making any adjustments, the Contractor shall review all available quality control and quality assurance inspection and test data with the Consultant.

#### **3.4.6.4. Surface Appearance and Tolerance**

The surface of the FDR mat shall be of uniform texture, free of severe segregation and any visually failed areas.

The compacted FDR mat shall be smooth and in compliance with the surface tolerance requirements for base course work as outlined in Specification Amendment AMC\_S155, "Amendment to Specifications 2.3 Grading, 3.1 Subgrade Preparation and all Base Course Specifications Regarding Surface Finish."

#### **3.4.6.5. Interim Lane Markings**

The Contractor shall install and maintain interim lane markings on all FDR surfaces that are exposed to overnight traffic.

Interim lane markings shall meet the requirements of Section 3.50.5.8, Interim Lane Markings, of Standard Specification 3.50, Asphalt Concrete Pavement - EPS..

#### **3.4.6.6. Curing of Stabilized FDR Material**

No traffic shall be allowed on the stabilized FDR material until the tight blading and final compaction is complete, and the material has sufficiently cured to support all traffic without

rutting, distorting or displaying any signs of instability.

When using an emulsion stabilizing agent, the asphalt concrete pavement or any other surface material shall not be placed until the FDR material has sufficiently cured such that the moisture content is 2% or less, or when a core can be easily extracted in the presence of the Consultant. The Contractor shall be responsible for obtaining cores to be given to the Consultant for moisture content determination and visual examination. The amount of time required for curing is typically 14 days or more, but will vary according to weather conditions. The actual curing time will be determined in the field based on existing conditions.

When foamed asphalt is used as a stabilizing agent, the wearing surface shall not be placed until the FDR material has been allowed to cure for a minimum of 2 days and the Contractor has demonstrated that the specification requirements have been met.

The asphalt concrete pavement or other specified wearing surface shall be placed no later than 30 days following FDR stabilization operations, provided the FDR material meets specification requirements. The Contractor shall schedule his operations to ensure that prior to winter shutdown, all accepted FDR is covered with the specified wearing surface or a minimum of one lift of ACP. A tack coat shall be applied to the FDR mat prior to paving in accordance with Specification 3.19 Prime, Tack and Fog Coats.

### 3.4.7. QUALITY CONTROL TESTING

#### 3.4.7.1. **General**

Quality control activities and testing shall be the responsibility of the Contractor throughout every stage of the Work. Tests that may be performed by the Consultant to determine compliance with specifications will be quality assurance tests, and will not be considered as quality control tests.

Unless otherwise directed by the Consultant, the Contractor shall submit all QC test reports and summaries, in writing, to the Consultant prior to 2:00 p.m. of the next working day.

The Contractor shall be responsible for all costs associated with quality control, and for obtaining quality assurance samples as specified herein.

The Contractor shall sample, test, and evaluate the FDR process in accordance with the minimum frequencies provided in the following Table:.

**Table 3.4.6 Quality Control Testing**

TEST OR ACTION	TEST METHOD	FREQUENCY
Daily Inspection Report	Note 1	Daily - Provide to the Consultant the Following Day
Process Depth Checks	Note 2	One per 200 m
Bulk Application Rate of Asphalt Stabilizing Agent	See Section 3.4.7.2	Each Tanker Load of Asphalt
Gradation of Additive Aggregate	ATT-25 or ATT-26	One per 8 Hour Shift of Crusher Operation or a Minimum of Three Tests, Whichever is Greater
Sampling and Testing of Stabilised FDR Mix	See Section 3.4.7.3	Two Per Lot (Note 3)
Cores of Stabilized FDR Base for Moisture Content Determination (Emulsion Only)	Note 4	As Required To Prove Curing Requirements Are Met Prior To Placing Surfacing Material

- Note 1 - The Contractor shall maintain a daily inspection report documenting the following information, where applicable:
- Date
  - Highway and direction of travel
  - Beginning and end stations
  - Total treatment area (m<sup>2</sup>) – Pulverization & stabilization
  - Calibration Control Settings
  - Measurements from the processing depth checks – Pulverization and stabilization
  - Water and asphalt counter reading (beginning, end, total)
  - Individual and moving average determinations of bulk application rates for asphalt stabilizing agent.
- Note 2 - To check that the automatic sensor system is functioning correctly, the actual depth of cut shall be physically measured by the Contractor at both ends of the milling drum at least once every 200 metres along the cut length.
- Note 3 - Once test results for two consecutive Lots indicate compliance to tensile strength requirements the frequency may be reduced to two samples and tests for every fifth Lot or a change in the composition of pavement materials, whichever occurs first.
- Note 4 - A minimum of three cores for each days production to be obtained using stratified random sampling procedures as described in ATT-56. Cores to be provided to the Consultant for visual inspection and moisture content determination.

#### **3.4.7.2. Bulk Application Rates**

The Contractor shall be responsible for calculating the bulk application rates of asphalt stabilizing agent applied. Bulk application rates shall be determined by measuring the area and depth stabilized, calculating the mass of FDR material treated, and calculating the mass of asphalt stabilizing agent used. Bulk application rates shall be calculated for each tanker of asphalt used. Individual results shall not be more than 0.6% above, or more than 0.4% below the established mix design value. A moving average of four individual bulk application rates shall be calculated beginning with the fourth bulk rate determination, and for each subsequent bulk rate determination. All moving averages so calculated shall not be more than 0.1% below the established mix design value.

#### **3.4.7.3. Moisture Content and Tensile Strength Testing of Stabilized FDR Material**

The Contractor shall obtain representative loose mix samples of the stabilized FDR material for moisture content and tensile strength testing at a minimum frequency of two samples per Lot, with a minimum period of 3 hours between sampling. Samples shall be a minimum of 15 kg each. The samples shall be obtained immediately following stabilization, and Marshall briquette specimens shall be formed within two hours of obtaining the sample. The briquettes and moisture content samples shall be properly labelled and bagged to protect against moisture loss.

The Contractor shall arrange to have the samples delivered to a testing laboratory of his choice. The testing laboratory shall have obtained pre-qualification status from the Department in the category of Mix Design – Marshall or have experience in preparing FDR mix designs.

For each sample, the moisture content of the stabilized FDR material shall be determined according to ATT-15.

Each briquette shall be tested for dry tensile strength, wet tensile strength and tensile strength ratio in accordance with AASHTO T283 and using the same conditioning, preparation and curing conditions as were used during the mix design.

Test results shall be reported to the Consultant in a timely manner and no later than 5 days following sampling.



The Lot Mean for Dry Tensile Strength and Tensile Strength Ratio will be determined as the arithmetic mean of all quality control test results plus, if available, quality assurance test results for the Lot.

#### 3.4.8. QUALITY ASSURANCE TESTING

The Consultant may, at any time, take samples and carry out testing and inspection of materials incorporated or being incorporated into the work. The Contractor shall co-operate with the Consultant for such sampling, testing and inspection. Consultant sampling and testing will not relieve the Contractor from any obligation to perform all work in strict accordance with the requirements of the Specifications.

Sample locations for routine quality testing will be randomly selected as far as practicable. This will not limit the Consultant from testing at any additional locations deemed necessary.

Frequency of testing for Density Control is outlined in ATT 58.

Following the completion of compaction and final grading operations, the Consultant will inspect the mat for compliance to surface appearance and surface tolerance requirements.

#### 3.4.9. COMPLIANCE REQUIREMENTS

All stabilized FDR material shall be compacted to an average of 98.0% of the applicable Control Density, with no single test less than 95% of the applicable Control Density.

The stabilized FDR mat shall be of the specified thickness and meet all surface tolerances.

Visually failed areas or areas with severe segregation which, in the opinion of the Consultant, may negatively affect the long term performance of the pavement structure will be rejected. All rejected areas shall be repaired by the Contractor to the satisfaction of the Consultant.

For areas rejected due to deterioration of the FDR material, the following methods of repair are acceptable but subject to the approval of the Consultant:

- Remove rejected area to a minimum depth of 50 mm and replace with hot mix Asphalt Concrete Pavement as approved by the Consultant.
- Reprocess rejected area to full depth using FDR equipment and adding additional asphalt and/or Portland cement stabilizers if directed by the Consultant.
- To meet specified surface tolerances, all deficient areas shall be re-profiled by grading or levelled with the same ACP mix to be used for the overlay.

All costs associated for repairing rejected FDR material are the responsibility of the Contractor, and no separate or additional payment will be made.

For areas of pulverized reclaim material or stabilized FDR material rejected due to underlying weak sub-base or subgrade materials, the following methods of repair are acceptable but subject to the approval of the Consultant.

- Reprocessing of the rejected area to full depth using FDR equipment and adding additional asphalt and/or cement stabilizers if directed by the Consultant.
- Complete subgrade excavation and removal of weak underlying materials in accordance with Standard Specification 3.1, Subgrade Preparation.

- Removal of failed FDR and granular base materials followed by incorporation of Portland cement into the underlying materials for stabilization. Granular fill and reclaimed materials may be used for backfill to ensure positive drainage is maintained.

Alternate methods proposed by the Contractor may be used subject to approval by the Consultant.

Payment for the repair of FDR material rejected due to weak underlying materials will be at the applicable unit rates.

### 3.4.10. MEASUREMENT AND PAYMENT

#### 3.4.10.1 **Full Depth Reclamation**

Accepted full depth reclamation will be measured in square metres of final finished surface from the top edge of FDR shoulder to the top edge of FDR shoulder. Width measurement for payment purposes will not exceed the dimensions shown on the Drawings unless modified by the Consultant.

Payment for accepted full depth reclamation will be made at the unit price bid for "Full Depth Reclamation", and will be full compensation for traffic accommodation; pulverizing and/or blending of all layers and materials, regardless of the number of phases or equipment passes used; all quality control sampling and testing; all mix designs; compaction, blading and shaping of the FDR material, both with and without additive aggregate; supplying water and adjusting the moisture content; supplying and adding an asphalt stabilizing agent; supplying and adding Portland cement or other additive; maintaining the treated surface; interim lane marking; supplying and applying asphalt material for tack coat; and all labour, materials, equipment, tools and incidentals necessary to complete the Work to the satisfaction of the Consultant.

#### 3.4.10.2 **FDR Additive Aggregate**

Measurement of FDR additive aggregate will be in tonnes.

Payment for FDR additive aggregate, when specified to be added, will be made at the unit price bid for "FDR Additive Aggregate", and will be full compensation for processing, hauling and placing the material; and quality control.

Payment for the supply of aggregate will be made in accordance with Specification 5.2, Supply of Aggregate.