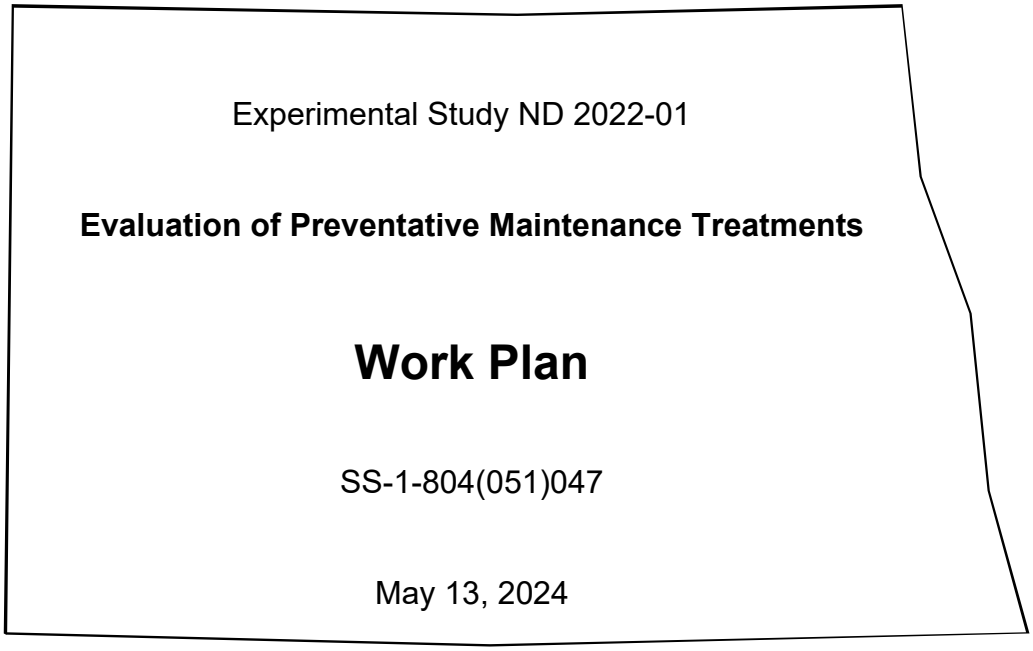
NORTH DAKOTA
DEPARTMENT OF TRANSPORTATION

MATERIALS AND RESEARCH DIVISION



Experimental Study ND 2022-01

Evaluation of Preventative Maintenance Treatments

Work Plan

SS-1-804(051)047

May 13, 2024

Prepared by

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T.J. Murphy

Disclaimer

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Evaluation of Preventative Maintenance Treatments

Purpose and Need

Pavement preservation plays a crucial role in highway agencies' efforts to prolong the service life of roads. By applying surface treatments strategically, agencies can extend pavement performance and delay distresses caused by both heavy traffic and environmental factors. A well-executed pavement preservation program aims to seal the pavement surface, preventing water infiltration into the pavement structure and mitigating the effects of stressors.

Preventive maintenance, a key component of pavement preservation, focuses on maintaining good pavements in optimal condition in a cost-effective manner compared to major rehabilitation efforts. An efficient pavement preservation program has the potential to reduce overall maintenance costs while simultaneously preserving or enhancing the condition of the road network.

This research initiative seeks to explore the implementation of multiple new and innovative preventive maintenance treatments. By investigating these treatments, the aim is to enhance the effectiveness and efficiency of pavement preservation strategies, ultimately contributing to the longevity and quality of road infrastructure.

Objective

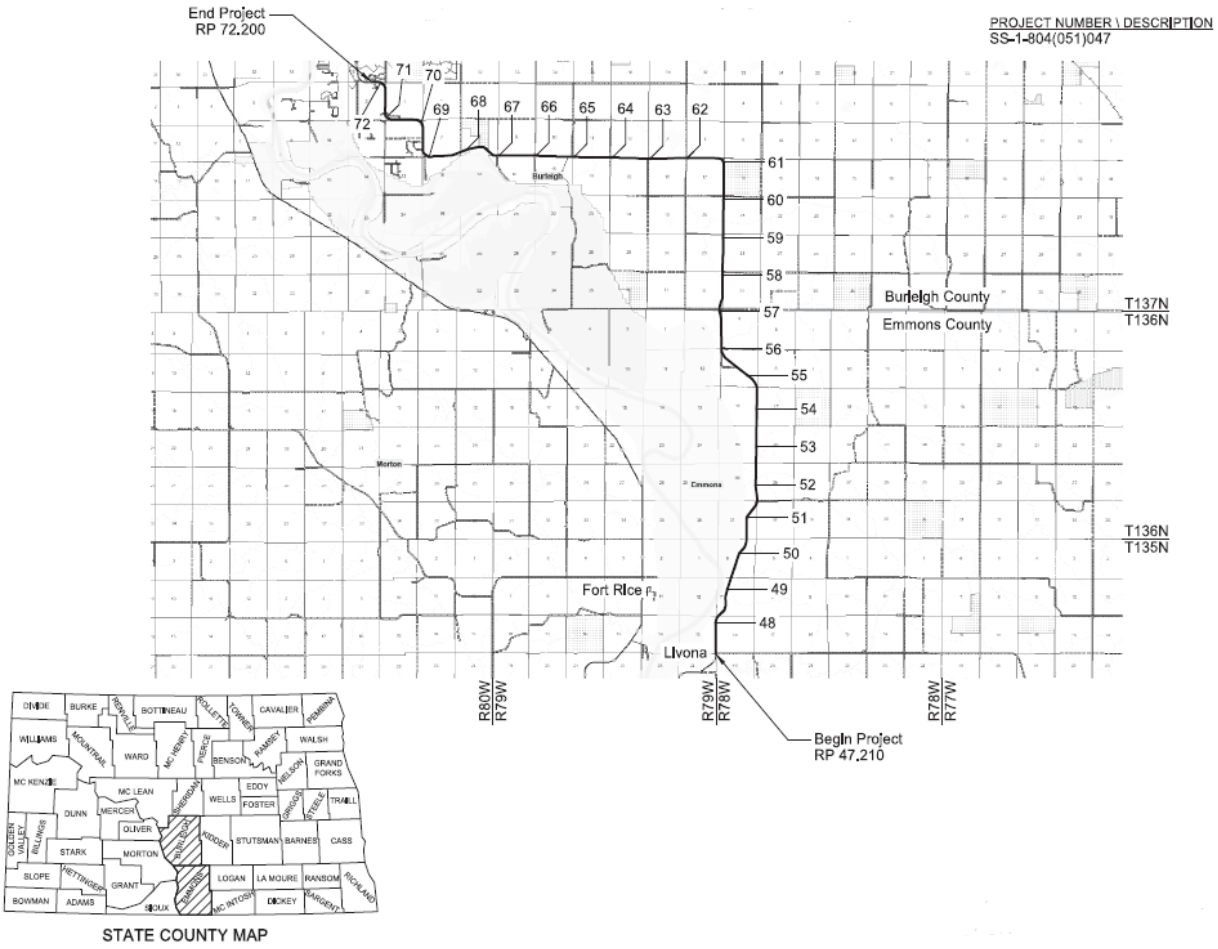
The objective of this research is to evaluate the effectiveness of multiple new preventative maintenance treatments for HMA roadways. Performance, constructability and design will be evaluated for the following HMA preventative maintenance strategies.

- Double Chip Seal
- Cape Seal
- RAP Cape Seal
- Double Micro-Surfacing
- RAP Double Micro-Surfacing
- Ultra-Thin Bonded Wearing Course
- Thin lay

Location

The experimental features are incorporated on a preventative maintenance project on highway 1804, project number SS-1-804(051)047, PCN 23336. The project will be constructed in the 2023 construction season. The experimental features are located south of Bismarck from RP 47.210 to RP 72.200 pictured below in figure 1.

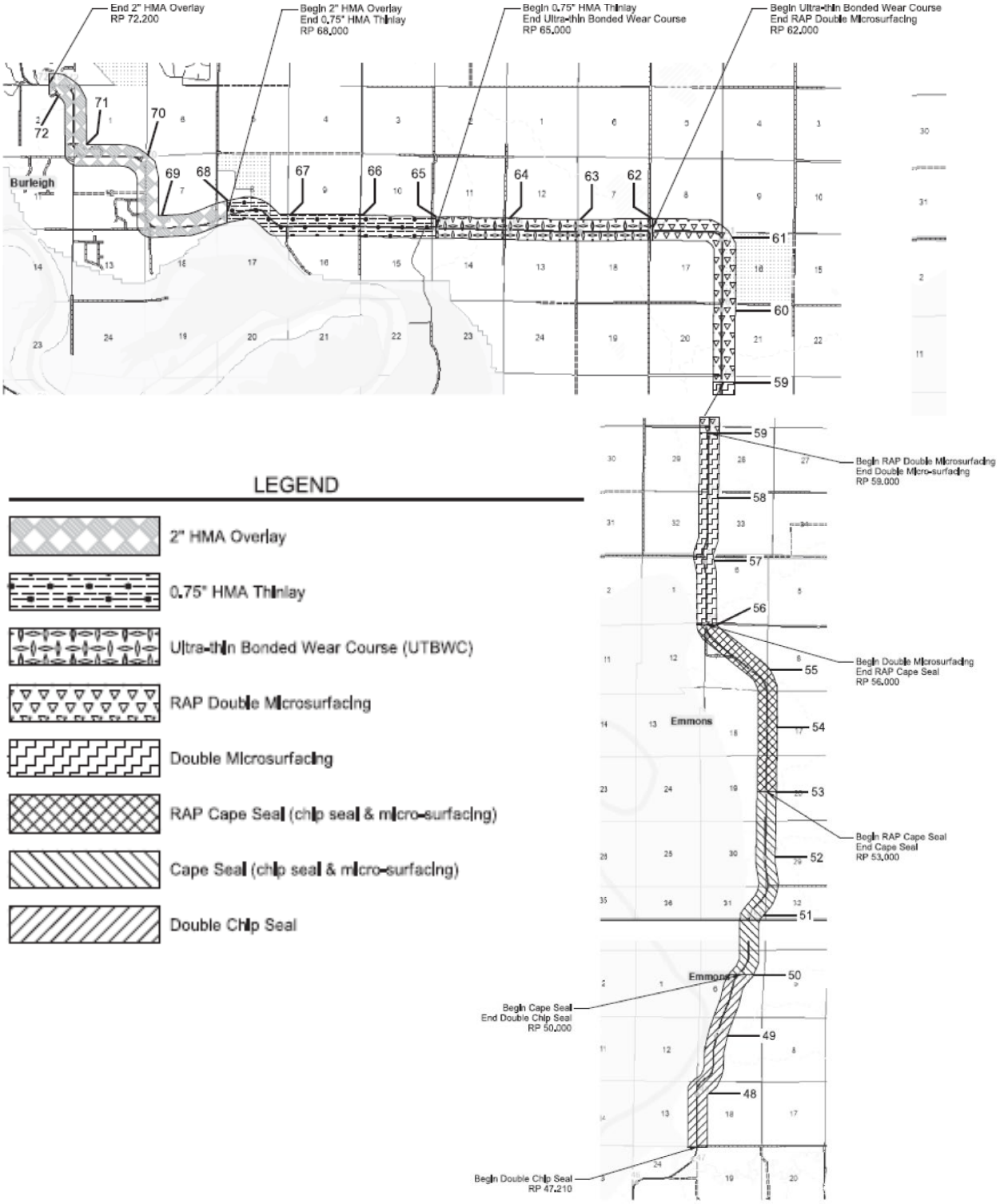
Figure 1: Project Location



Design

The experimental features have been incorporated onto the roadway as three-mile test cells illustrated below in figure 2. A map of the test cells and legend can be found on the following page. The test cells were developed and implemented onto the project through special provisions and plan notes. The plans and special provisions can be found in Appendix A.

Figure 2:Test Section Outline



Project Historical Information

The roadway historical construction records can be found in Appendix B. The roadway was originally constructed in 1967-1971 and consisted of 3”-4” of emulsified aggregate base with a 1.5” of asphalt pavement and received a chip seal in 1987 and 1997 with some intermittent contract patching. In 2008 a 2” overlay was placed, and chip sealed in 2011.

Traffic

RP 47.21 - RP 57.067 Traffic

Year	Passenger Car	Trucks	Total	30TH Max Hr	Flexible EASLs
2019	270	20	290	30	15
2022	275	30	305	35	15

RP 57.067 - RP 61.148 Traffic

Year	Passenger Car	Trucks	Total	30TH Max Hr	Rigid EASLs
2019	210	20	230	25	10
2022	335	35	370	40	15

RP 61.148 - RP 66.059 Traffic

Year	Passenger Car	Trucks	Total	30TH Max Hr	Rigid EASLs
2019	530	25	555	60	10
2022	550	45	595	60	20

RP 66.059 - RP 71.000 Traffic

Year	Passenger Car	Trucks	Total	30TH Max Hr	Rigid EASLs
2019	530	50	580	60	25
2022	725	55	780	80	25

Scope

The project will be evaluated annually for 5 years or until replacement if it is determined that the condition warrants treatment before the end of the evaluation period. Materials and Research will also reserve the option to extend the evaluation period if the treatments performance warrants monitoring after the evaluation period. The project will be evaluated on the following criteria each summer:

- Determine the constructability of each treatment.
    - Evaluate Special Provision Documents.
    - Survey Construction Staff.
- Performance Monitoring
    - Pathways Roadway Condition Monitoring
    - Annual Inertial Profiling Ride Index
    - Visual Onsite Surveys.

Materials and Research will publish a construction report followed by biennial performance reports.

Construction

During the 2023 construction season, Central Specialties Inc. successfully completed the test section without notable issues, thanks to strict adherence to specifications and effective implementation of special provisions. A significant lesson learned revolved around the processing of RAP chips, where excess oil caused clogging of screening sieves, resulting in reduced screening efficiency. Despite this challenge, the project timeline remained unaffected due to well-planned phasing, allowing ample time for material production.

Notably, the cost per mile of the test sections is detailed in the table below. It's essential to recognize that as an experimental feature, costs may vary when bid in larger quantities or as a sole treatment.

These insights will guide future project strategies, highlighting the importance of proactive measures to mitigate potential challenges during construction phases.

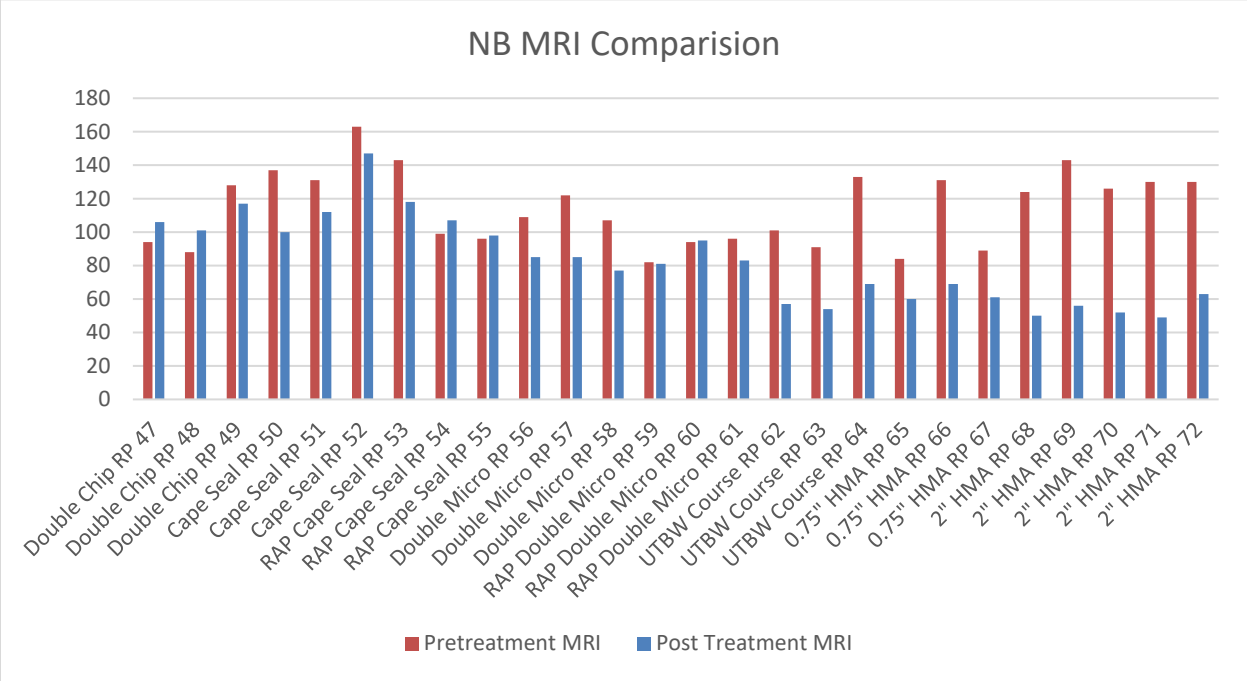
Treatment	Cost Per Mile	Mile Point
Double Chip Seal (0.5”)	$193,749	47.21 to 50
Cape Seal (0.5”)	$166,644	50 to 53
RAP Cape Seal (0.5”)	$169,938	53 to 56
Double Micro-Surfacing	$160,670	56 to 59
RAP Double Micro-Surfacing	$163,785	59 to 62
Ultra-Thin Bonded (.75”	$403,968	62 to 65
HMA 4.75mm (0.75”)	$261,836	65 to 68
FAA 43 2” Overlay (Control)	$389,486	68 to 72.2
Urban HMA 9.5mm (1.25”)	$341,706	72.2 to 78.18

Table 1: Experimental Section Cost Per Mile

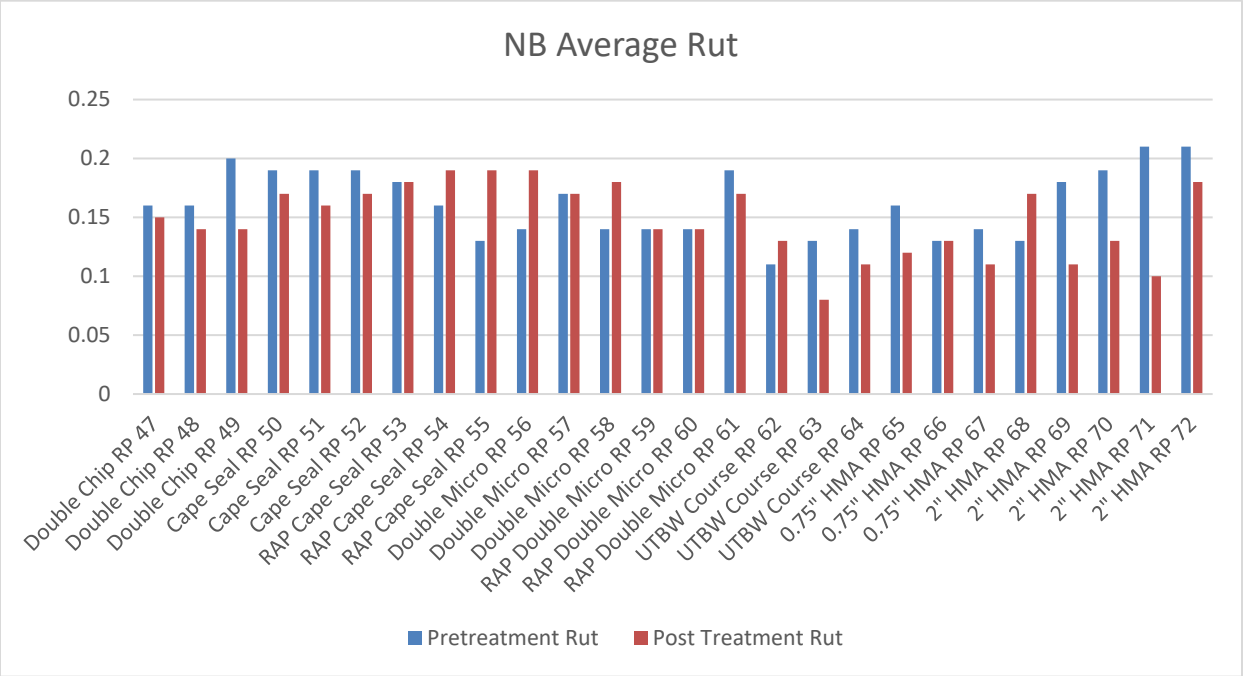
Performance

The performance data was collected in the spring of 2023 before any treatments were applied, and again after the experimental sections were constructed. The following graphs depict the conditions recorded by the pathways van.

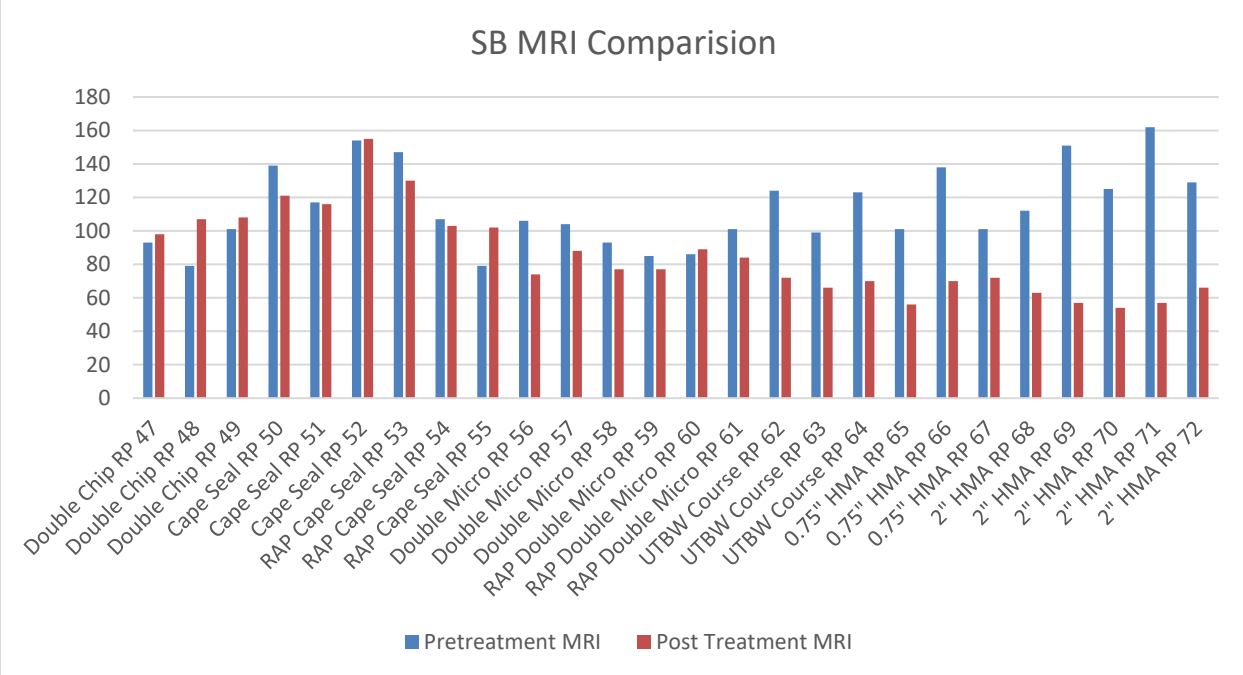
Graph 1: NB MRI Summary



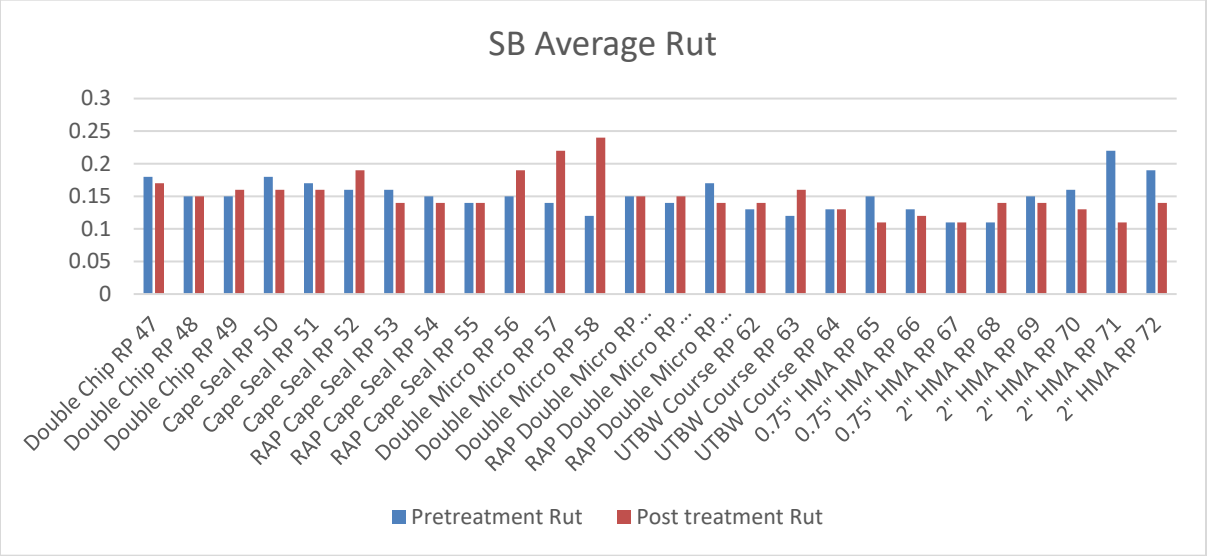
Graph 2: NB Average Rut



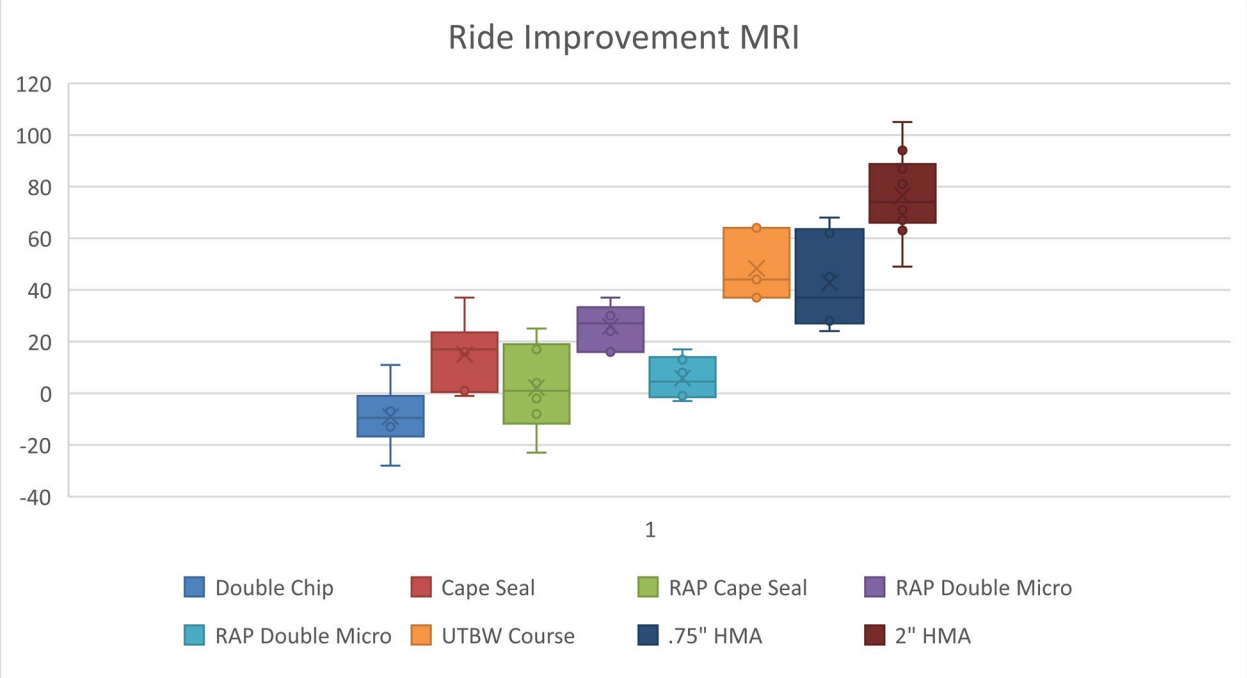
Graph 3: SB MRI Summary



Graph 4: SB Average Rut



Graph 5: MRI Improvement



These visual representations offer a clear comparison of the road conditions before and after the implementation of the experimental treatments. Analyzing these graphs will provide valuable insights over time into the effectiveness of the treatments in improving road quality and ride comfort.

Summary

The road maintenance project has progressed well, with all test sections successfully constructed and special provisions effectively implemented. Initial findings indicate that thicker preventive maintenance operations, such as the UTBW course, .75" HMA thin lay, and 2" Overlay, have significantly improved ride quality. The 2" Overlay stands out with an impressive average reduction of close to 80 MRI, demonstrating its effectiveness.

While other treatments have shown less pronounced improvements, there is still evidence of positive impact, likely attributed to micro milling operations, resulting in a reduction of 10 to 20 MRI in ride quality. Annual performance monitoring will continue to track the long-term effectiveness of these treatments, providing valuable insights for future maintenance strategies and investments.

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

ULTRA THIN BONDED WEARING COURSE

PROJECT 1-804(051)047 – PCN 23336

DESCRIPTION

This work is the construction of an Ultra-Thin Bonded Wearing Course (UTBWC) on a prepared pavement. An UTBWC is the application of a polymer modified emulsion membrane followed immediately with and ultrathin wearing course mixture.

EQUIPMENT

A. General.

Equipment	Section
Smooth-Faced Steel-Wheel Roller: Tandem – Type A	151.03 A.2
Smooth-Faced Steel-Wheel Roller: Tandem – Type B	151.03 A.3
Bituminous Trucks	152.01
Bituminous Tank Trucks	152.01 E

B. Paver

Provide a paver that meets the requirements of Section 154.02 A, “Pavers” with the following modification.

Supply a paver that is equipped with integrated spray bars in front of the screed for applying tack coat immediately before the asphalt is laid.

MATERIALS

A. Asphalt Cement.

Item	Section	Material
Polymer Modified Emulsion membrane	818.02 E	CRS-2P
Asphalt Cement	818	PG58V-34

The Engineer will accept asphalt cement as outlined in the Combined State Binder Group agreement for North Dakota. The Contractor shall obtain samples of this material under the observation of the Engineer. The Engineer will take immediate possession of the samples.

B. Mix Design.

Develop a mix design that conforms to the following requirements.

TABLE 1		
Sieve Size	**Percent Passing**	**Production Tolerance**
1/2 Inch	100	-
3/8 Inch	85 – 100	± 5
1/4 Inch	30 – 50	± 4
#4	24 – 40	± 3
#8	21 – 32	± 3
#16	16 – 26	± 3
#30	12 – 20	± 2
#50	8 – 16	± 2
#100	5 – 10	± 1
#200	4.0 – 7.0	± 1.0

Table 2		
Test	**Criteria**	**Test Reference**
Asphalt Content, %	4.8-6.0	
Adj. AFT (Calculated)	10.5 micrometer minimum	
Draindown Test	0.10 percent maximum	AASHTO T 305
Lottman (TSR)	80 percent minimum	

C. Coarse Aggregate

Provide coarse aggregate that is uniformly blended consisting of material that meets Table 3.

Table 3		
Property	**Method**	**Requirements**
LA Abrasion Coefficient, maximum % loss	AASHTO T 96	25
Maximum % passing the #200 sieve, %	ND T 11, ND T 27	2
Soundness, maximum % loss	AASHTO T 104	10
Fractured particles	AASHTO T 335	100%

D. Fine Aggregate

Provide fine aggregate that is composed of 100% crushed stone with a minimum sand equivalent of 60%

CONSTRUCTION REQUIREMENTS

A. General.

Place the UTBWC when the air and surface temperature is above 50 °F.

Do not place bituminous mixture on ponded surfaces, or when weather conditions prevent the proper handling and finishing of the bituminous mixtures.

B. Surface preparation.

Remove deleterious material from the surface.

Cover any manhole covers, water boxes, catch basins or other utility structures with plastic or felt.

Apply tack with the spreading and finishing machine at a temperature of between 120 and 180 °F. Monitor the rate of tack over the width of the machine. Maintain the tack rate of 0.20 Gal/SY ± 0.05 Gal/SY.

C. Spreading and Finishing.

Use bituminous pavers to spread and finish mixtures to the required section leaving the mixture uniformly dense, smooth, and free from irregularities. In locations where it is impractical to use normal laydown equipment the Engineer will allow other methods.

Supply mix that is uniform and homogeneous. The Engineer will reject loads of mix or sections of pavement containing uncoated batches of aggregate or segregated materials.

Remove and replace material that is visibly segregated. If a paver placed the material, remove the segregated material to the full width of the paver. If the material was placed by hand, remove the full area of segregated material, plus an additional 6 inches around the entire segregated area.

D. Compaction.

Remove all surface irregularities before beginning compaction.

Sequence rolling operations and select the type and the number of rollers to match production and to attain the required density before the mat temperatures fall below 185°F.

Sequence rolling so each area of the mat receives a minimum of two passes with a tandem roller before the mat temperature falls below 180°F.

Compaction. Compaction shall consist of each area of the mat receiving a minimum of two passes with a tandem roller, before the material temperature has fallen below 180 °F (80 °C).

In areas not accessible to rollers, compact the pavement mat with hand or mechanical tampers.

Do not allow rollers to stop on freshly placed UTBWC.

METHOD OF MEASUREMENT

BASIS OF PAYMENT

Pay Item	Pay Unit
UTBWC	SY

Such payment is full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

THINLAY

PROJECT 1-804(051)047 – PCN 23336

DESCRIPTION

This work consists of constructing a thin HMA overlay

Sample and test as outlined in the Field Sampling and Testing Manual

EQUIPMENT

A. General.

Equipment	Section
Self-Propelled Pneumatic-Tired Roller	151.01 C
Smooth-Faced Steel-Wheel Roller: Tandem – Type A	151.03 A.2
Smooth-Faced Steel-Wheel Roller: Tandem – Type B	151.03 A.3
Vibratory Roller	151.03 B
Combination Roller	151.04
Bituminous Trucks	152.01 D
Bituminous Tank Trucks	152.01 E
Bituminous Equipment	154

When air temperatures fall below 50˚ F at any place along the haul route of the mix, deploy the tarps installed on the bituminous trucks.

B. Paver.

Provide a paver that meets the requirements of Section 154.02 A, “Pavers”. When using the 4.75 mm mixture, supply a paver that meets the requirements of Section 154.02 A, “Pavers” with the following modification:

Supply a paver that is equipped with integrated spray bars in front of the screed for applying tack coat immediately before the asphalt is laid.

MATERIALS

A. General.

Item	Section
Bituminous Material	818

B. Asphalt Cement.

The Engineer will accept asphalt cement as outlined in the Combined State Binder Group agreement for North Dakota. The Contractor shall obtain samples of this material under the observation of the Engineer. The Engineer will take immediate possession of the samples.

C. Aggregate.

Develop a mix design that contains an aggregate gradation that conforms to the requirements in Table 01.

Table 01
Aggregate Gradation for Mix Design

Sieve Size	Superpave – 9.5 mm		Superpave – 4.75 mm	
	Min	Max	Min	Max
½ Inch	100	100		
3/8 Inch	97	100	100	100
#4		90	90	100
#8	32	67		90
#16			30	55
#30	15	35	15	35
#200	2.0	10.0	2.0	10.0

Provide aggregate that meets the requirements in Table 02.

Table 02

Test Designation	Test Name	Criteria
ND T 176	Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test	40% minimum
ND D 4791	Test Method for Flat Particles, Elongated Particles, or Flat Elongated Particles in Coarse Aggregate	10% maximum
AASHTO T 96	Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine	40% maximum
ND T 113	Lightweight Pieces in Virgin Aggregate	5.0% maximum

D. Superpave Mix Properties.

Provide mix that meets the requirements of Table 03. Base the fine aggregate angularity (FAA) on the designation of the bid item.

Table 03

Property	FAA 43	FAA 45
Fractured Particles in Coarse Aggregate (minimum)	75%	85%
Fine Aggregate Angularity (minimum)	43%	45%

Table 03		
Property	**FAA 43**	**FAA 45**
Gyratory Effort, # of Gyrations	N_{ini} = 7, N_{des} = 75, N_{max} = 115	N_{ini} = 7, N_{des} = 75, N_{max} = 115
Voids filled with Bitumen	65-78%	65-75%
$\%G_{mm}$ @ N_{ini} (maximum)	89%	89%

The superpave mix properties shown in Table 03 will be determined according to the methods shown in Table 04.

Table 04
Methods for Determining Superpave Mix Properties

Fractured Particles in Coarse Aggregate	NDDOT 4
Fine Aggregate Angularity	ND T 304
Gyratory Effort, # of Gyrations	AASHTO R 35
Voids filled with Bitumen	AASHTO M 323, ND T 166
$\%G_{mm}$ @ N_{ini}	AASHTO M 323, ND T 166

E. Preparation of Aggregates.
When using a drum-dryer mixer, prepare aggregate so that the moisture content of the bituminous mixture is less than 1 percent.

Screen aggregates used in a cold-feed control into two or more fractions consisting of at least 1 fine and 1 coarse aggregate stockpile. Feed aggregate from the stockpile into separate compartments for accurate proportioning into the mixer.

CONSTRUCTION REQUIREMENTS

A. Contractor Quality Control (QC).

1. Quality Control Personnel.
Provide the following personnel:
- Certified Aggregate Field Lab Tester to be on the project during aggregate production;
- Certified Aggregate Field Lab and Asphalt Mix Tester to be on the project during asphalt mix production;
- Certified Asphalt Pavement Inspector to be on the project during paving operations; and
- Certified Asphalt Mix Controller to be on the project during paving operations.

Ensure that all personnel performing tests on materials used in the paving operation are certified as outlined in the Department's Technical Certification Program (TCP). The requirements of the TCP can be found on the Department's website, www.dot.nd.gov.

2. Quality Control Plan.
Before beginning work, submit a copy of the QC plan to the Engineer. Provide and maintain copies of the plan at the Quality Assurance (QA) and QC laboratories. Provide the following minimum information in the plan:

a. The names and phone numbers of the individuals responsible for the QC program.
b. A listing of the personnel responsible for the QC testing and their Technician ID and qualifications.
c. An organizational chart indicating lines of authority, including names and phone numbers.
d. Details of the QC plan addressing the following items:
   - Pit operations and methods used to control uniformity, limiting segregation, and efficiently utilizing the aggregate resources of the pit;
   - Plant operations listing proposed equipment and method of operations;
   - Site plan drawing of plant;
   - Testing frequency for both aggregate production and mix production; and
   - Discussion of how the QC program responds to the need for corrective action.

An example quality control plan is available on the Department's website.

B. Engineer's Quality Assurance Plan.
The Engineer will provide a quality assurance plan to the Contractor at the time the Contractor submits the quality control plan specified in Construction Requirements A.2, "Quality Control Plan." The quality assurance plan will contain:

- The names and phone numbers of the individuals responsible for the QA program.
- A listing of the personnel responsible for the QA testing and their Technician ID and qualifications.
- An organizational chart indicating lines of authority, including names and phone numbers.

C. Pit Operations and Stockpiling of Aggregate.

1. General.
Perform the tests required in Section 430.02 A.2, "Contractor Testing" in the Field Sampling and Testing Manual. Provide copies of test results for each stockpile of aggregate by noon the day following the tests.

Before the start of bituminous mix production, stockpile 50 percent of the required quantity of bituminous mixture at the plant.

During bituminous mix production, maintain 25 percent of the required quantity of bituminous mixture to finish production.

2. Determination of Specific Gravity.
If the specific gravity values determined by the Contractor and Engineer as required by Section 430.02, "Quality Control Testing" of the Field Sampling and Testing Manual correlate within 0.040, proceed with developing a mix design using the Contractor's averaged specific gravity values.

If the specific gravity values determined by the Contractor and Engineer as required by Section 430.02, “Quality Control Testing” of the Field Sampling and Testing Manual do not correlate within 0.040, choose one of the following options:

- Perform the tests together with the Engineer at an agreed upon location; or
- Resolve the testing differences according to the dispute resolution procedures in Section 430.04, “Dispute Resolution” of the Field Sampling and Testing Manual.

Once resolved, proceed with the development of a mix design using the determined number for the tests performed with the Engineer or the number determined by the dispute resolution procedure.

D. Mix Design.

1. General.

Develop the mix design according to NDDOT 2. Use the Department mix design spread sheet available at www.dot.nd.gov. Do not begin production of hot bituminous pavement before the Department approves the mix design.

If the project will contain both recycled and non-recycled pavements, submit one mix design containing recycled material and one without recycyled material.

Submit the mix design a minimum of 10 calendar days before beginning paving operations. The Engineer will review the mix design. If the Engineer does not approve the mix design, revise the mix design and submit the revised mix design. Allow 10 calendar days for the Engineer to review a revised mix design before beginning paving operations.

When making the blend determinations for the mix design, use the average of the production samples value for each sieve from each stockpile.

Base the mix design on the criteria specified in Table 05 and develop the mix design according to the standards outlined in Table 06.

TABLE 05
Hot Mix Asphalt Testing Criteria

Procedure/Property /Test	Superpave – 9.5 mm	Superpave – 4.75 mm	Reference
Voids in Mineral Aggregate	15.0 Min	16.0 Min	AASHTO M 323 ND T 166
% G_{mm} @ N_{max}	98.0 Max	98.0 Max	AASHTO M 323 ND T 166
Dust/Effective Asphalt Ratio	0.8 – 1.6	1.0 – 2.0	AASHTO M 323 ND T 166
Asphalt Film Thickness [1] (Microns)	7.5 - 13	7.5 - 13	Determined by Department’s mix design program.

TABLE 06
AASHTO SUPERPAVE MIX DESIGN STANDARDS

Designation	Title
ND T 312	Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
AASHTO R 35	Practice for Superpave Volumetric Design for Hot Mix Asphalt
AASHTO R 30	Mix Conditioning of Hot Mix Asphalt (HMA)
AASHTO M 323	Specification for Superpave Volumetric Mix Design
ND T 166	Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens

Submit a revised mix design if:

- utilizing aggregate from sources not initially submitted;
- processing the aggregate using a different crusher; or
- using a different type or grade of bitumen.

Allow 10 calender days for the Department to review the revised mix design before incorporating the material into the work.

If the source of bitumen changes from the approved mix design, immediately notify the Engineer of the change and provide the relevant information related to the new source. The Engineer may request a new mix design. If the Engineer requests a new mix design, submit the necessary materials and allow 10 days for the Department to review the revised mix design before incorporating the material into the work.

2. Items to be Submitted.

Submit the following items with each mix design:

a. An aggregate sample representing each stockpile used for the mix design. The total weight of material shall be approximately 150 lbs.

b. Eight one-quart cans of PG asphalt. The PG asphalt shall be the same grade specified on the plans and from the supplier that will be used on the project.

When multiple grades of PG asphalt are specified, one grade may be supplied, but it must be the same grade used to develop the mix design.

c. Approximately 30 lbs of loose asphaltic concrete mix prepared at the optimum asphalt content recommended by the mix design.

d. The Contractor shall submit a mix design that contains the following elements:

1. The percentage of aggregate passing each of the specified sieves.
2. The percent asphalt cement to be added to the mixture.
3. The target air voids will be 3.0%.
4. The maximum specific gravity of the mixture obtained in the laboratory.
5. The bulk specific gravity of the mixture obtained in the laboratory.
6. The percent VMA of the mixture obtained in the laboratory.
7. Calculated film thickness (microns).
8. Calculated dust/asphalt ratio.

9. %Gmm @ Nini
10. %Gmm @ Nmax

E. QC Testing.

1. General.

During production of the bituminous mix, perform sampling and testing on the aggregate and bituminous mix as the mix is being produced and placed on the roadway.

Perform the tests specified in Section 430.02, “Quality Control Testing” of the Field Sampling and Testing Manual at the designated frequencies. During aggregate production, test results must be made available by noon the day following the test. During mix production, furnish copies of test results upon completion of the test.

If the QC test results for ND T 176 or ND T 113 indicate uniform results, the Engineer may issue a written notice reducing the frequency of these tests.

2. Determination of Asphalt Content.

Under the observation of the Engineer, determine the asphalt content each time a gradation test is taken. Base the asphalt content on readings from the totalizers for the aggregate and the asphalt as outlined in SFN 18674, “Asphalt Content & Virgin Aggregate Determination”.

3. Sample Splitting.

The Engineer will take possession of one half of the split QC sample and will perform testing on a portion of the material, as necessary.

The portion of the sample submitted to the Engineer will be retained for 24 hours after the QA test representing the lot of material has been performed. Either the Engineer or Contractor may request to have the remaining portion of the sample tested within the 24 hour timeframe. If a request is made, the Engineer will test the remaining portion of the QC sample and the Engineer’s results will be used as the basis for acceptance of the aggregate.

4. Documentation.

Maintain complete records of all process quality control tests. Record all test results and calculations and document results on Department provided forms. The required forms are available on the Department’s website www.dot.nd.gov. The proper forms for individual tests are listed in the Field Sampling and Testing Manual.

Maintain control charts at the QC laboratory. Record test results on the control charts immediately upon completion of the test. Record the following parameters on the control charts:

- Gradation of the control sieves (1/2 Inch, #4, #30, and #200), (ND T 27 and ND T 11);
- Asphalt Content;
- Theoretical Maximum Specific Gravity, (ND T 209);
- Bulk Specific Gravity, (ND T 166);
- Percent Air Voids of field Gyratory samples;
- Daily average Air Voids percentage of the cores;

- Average Daily Density;
- Fines/Asphalt Ratio;
- Asphalt Film Thickness (microns); and
- Fine Aggregate Angularity.

Control charts must display:

- Single test control limits for each test parameter;
- Individual test results;
- Moving average control limits; and
- Moving average of the last four tests.

Color code the moving average results and control limits, and the single tests and control limits.

Make the control charts available at the QC laboratory and accessible for review by the Engineer during the paving operations. Submit complete control charts upon completion of the paving operations.

5. Control Limits.

The field test results may vary from the mix design target values as shown in Table 07.

TABLE 07
ALLOWABLE WORKING RANGES

Test/Assessment		Single Test Target Value Control Limit	Moving Average Target Value Control Limit
Asphalt Content (based on totalizer reading)		±0.30	±0.24
ND T 11 and ND T 27 and	Sieve Analysis of Fine and Coarse Aggregates (Control Sieves)		
	1/2"	±6.0	±5.0
	3/8 “	±6.0	±5.0
	#4 Sieve	±6.0	±5.0
	# 8 Sieve	±5.0	±4.0
	#16 Sieve	±5.0	±4.0
	#30 Sieve	±5.0	±4.0
	#200 Sieve[1]	±2.0	±1.5
SFN 50289	Percent Air Voids	1.5% - 5.0%	2.0% - 4.5%
	VMA	-0.5	-0.5
ND T 113	Lightweight Pieces in Aggregate	Not more than the maximum specified	
NDDOT 4	Percentage of Fracture Particles in Coarse Aggregate	Not less than the minimum specified	
ND T 304	Fine Aggregate Angularity	Not less than the minimum specified	

TABLE 07
ALLOWABLE WORKING RANGES

Test/Assessment		Single Test Target Value Control Limit	Moving Average Target Value Control Limit
ND D 4791	Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate	Not more than the maximum specified	
ND T 176	Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test	Not less than the minimum specified	

[1] Not to exceed the maximum specified in Table 01.

a. Single Test Target Values.
If an individual test falls outside the single test target value control limits, take immediate corrective action. After implementation of the corrective action, collect a sample and conduct the test that fell outside the control limits. If the test following the corrective action falls outside of the control limits discontinue paving operations until the cause is found and corrected. Resume paving operations only after obtaining approval from the Engineer.

The test following the corrective action is used to determine the effectiveness of the corrective action. It is not used for acceptance of material and will not be factored into the moving average.

If, in an individual gradation test, a single control sieve falls outside the single test target value control limits, continued production is allowed only if the air voids are within the control limits and the material passing the #200 sieve does not exceed the maximum specified in Table 01.

Discontinue paving operations if 2 consecutive tests exceed the single test target value control limit for any of the following:

- ND T 113, Lightweight Pieces in Aggregate;
- ND T 304, Fine Aggregate Angularity;
- NDDOT 4, Percentage of Fracture Particles in Coarse Aggregate; or
- ND T 176, Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test.

Resume paving operations only after taking corrective action and obtaining approval from the Engineer.

b. Moving Average Target Values.
The moving average for each test is determined using the 4 most recent test results.

If the moving average for a test trends toward the moving average target value control limits, take corrective action. After implementation of the corrective action collect a sample and conduct the test that is trending towards the moving average control limits. The test following the corrective action is used to determine the effectiveness of the

corrective action. It is not used for acceptance of material and will not be factored into the moving average. Document the corrective action.

If the moving average for a test exceeds the moving average target value control limits, continued production is allowed only if the air voids are within the control limits and the material passing the #200 sieve does not exceed the maximum specified in Table 01.

If the air voids are outside the control limits or the material passing the #200 sieve exceeds the maximum specified in Table 01, perform one of the following actions:

- Implement corrective measures to produce mix that is based on the mix design; or
- Request that new target values be set if the test results indicate that adjustments to the target values are necessary. Implement the adjusted target values only after receiving the Engineer's written approval.

If the moving average for air voids exceeds the moving average control limit, discontinue paving operations and implement corrective measures. The Engineer may allow continued paving if satisfied with the corrective measures. Resume quality control testing when the plant has started and operations are equalized.

F. Surface Preparation.

Remove deleterious material from the surface.

Correct local irregularities in the existing surface before placing the first lift of bituminous material. If milling is specified, correct local irregularities after milling. Apply a tack coat to the surface before correcting the irregularities. Use the same type of mix that is required for the subsequent lift. Use self-propelled pneumatic-tired rollers to roll and compact the mix.

The mix required for correcting local irregularities will be deducted from the total mix used for the project, meaning that the subsequent lift of pavement will be thinner than originally planned.

Apply a tack coat to the surface and to the exposed edges of longitudinal and transverse joints before placing bituminous pavement. Apply a double application of tack coat to longitudinal joints and a minimum of one inch on either side of the joint. Apply a tack coat on a previously placed layer or surface of pavement before placing the next lift.

G. Patching.

Remove existing broken or unstable surface material and replace that material with the same mixture specified for the next course.

Place the bituminous material in lifts not to exceed 3 inches and compact the material. Allow the patch material to cool to 130°F before placing additional material. If patching is required during the paving operation allow the patch material to cool to 185°F before placing additional material.

H. Spreading and Finishing.

1. General.

Do not place bituminous mixture on a damp pavement surface or when weather conditions prevent the proper handling and finishing of the bituminous mixtures.

Use bituminous pavers to spread and finish mixtures to the required section leaving the mixture uniformly dense, smooth, and free from irregularities. In locations where it is impractical to use normal laydown equipment the Engineer will allow other methods.

Supply mix that is uniform and homogeneous. The Engineer will reject loads of mix or sections of pavement containing uncoated batches of aggregate or segregated materials.

Remove and replace material that is visibly segregated. If a paver placed the material, remove the segregated material to the full width of the paver. If the material was placed by hand, remove the full area of segregated material, plus an additional 6 inches around the entire segregated area.

Place bituminous mixture so a single lane is not more than one day's run in advance of any adjacent lane. Leveling courses are excluded from this requirement.

Do not place bituminous pavement on bridge decks.

2. Air and Surface Temperature Requirements.

Place bituminous mix without supplementary admixture when the temperatures are at or above the requirements in Table 08. Include a supplementary admixture such as Evotherm, AD-here LOF 65-00 EU, or an approved equal in the bituminous mixture when placing bituminous mix when temperatures are within the ranges shown in Table 09. Do not place bituminous mix when temperatures are below those shown in Table 09.

Table 08
Standard Paving Temperatures

Compacted Thickness	Air Temp for Surface Course	Air Temp for Subsurface Course and Approaches	Existing Mat
1-1/2 inches or less	45°F	40°F	40°F

If placing bituminous mix according to Table 09, submit the supplementary admixture manufacturer's dosage rate and any changes to the mix design. The supplementary admixture may be added to the asphalt binder by the supplier or refiner, or by the Contractor at the asphalt plant. Add the admixture to the binder according to the supplementary admixture manufacturer's recommendations. If the admixture is added at the plant, equip the plant with a metering device that records the rate of admixture. Tie the metering device into the same system that measures the other components of the mix.

Table 09
Paving Temperatures Using Supplementary Admixtures

Compacted Thickness	Air Temp for Surface Course	Air Temp for Subsurface Course and Approaches	Existing Mat
1-1/2 inches or less	40°F - 45°F	35°F - 40°F	35°F - 40°F

Measure the existing mat temperature using one of the following methods:

- Using an infrared sensing thermometer; or

- Insert a conventional thermometer into a 1 inch deep hole in the pavement. Fill the hole with water, oil, or grease.

3. Mix Temperature Requirements.
Discharge mix from the mixer with a temperature no higher than the bituminous material manufacturer's recommendation. If there are no recommendations on maximum mix temperature, discharge mix with a maximum temperature of 300°F.

When the ambient temperature is 60°F or higher, place mix with a minimum laydown temperature of 240°F. When the temperature is below 60°F, place mix with a minimum laydown temperature of 260°F.

I. Compaction.

1. General.
Remove all surface irregularities before beginning compaction.

Sequence rolling operations and select the type and the number of rollers to match production and to attain the required density before the mat temperatures fall below 185°F.

In areas not accessible to rollers, compact the pavement mat with hand or mechanical tampers.

2. Calculated Density.

a. General.
Use calculated density on mainline pavement, interstate crossroads, ramps, turn lanes, rest area approaches, and parking lots.

Calculated density will not apply to the 4.75 MM HMA mix.

b. Coring.

(1) General.
Obtain pavement cores at locations designated by the Engineer under the observation of the Engineer.

Use a machine that cuts a cylindrical core sample without disturbing the density of the sample. Complete coring on or before the working day following the placement of the lift. Obtain a core with a smooth outer surface, no distortion of the cylindrical shape, and no displacement of the aggregate particles. Obtain a core that is 4 to 6 inches in diameter and the full depth of the in place asphalt.

Fill core holes before placing the subsequent lift of pavement. If there is no subsequent lift of pavement, fill the core hole within 24 hours of obtaining the core. Remove free standing water before filling core holes. Fill core holes in 2 inch lifts using material from the same mix design used on the roadway. Compact each lift using a hand tamper.

(2) Pavement Density Cores.
Use a masonry saw to cut the core so that only the layer to be tested is removed.

Label each core, using a system approved by the Engineer, to identify the location from which the core was obtained.

(3) Pavement Thickness Determination Cores.
Obtain pavement thickness determination cores after the final lift of pavement has been placed. Label the cores. The Engineer will take possession of these cores immediately upon extraction. Do not cut these cores.

3. Ordinary Compaction.

a. General.
Use ordinary compaction on FAA 43 – 4.75 MM HMA as well as on shoulders, driveways, section line approaches, bike paths, leveling courses, and patches.

Ordinary compaction consists of breakdown rolling, intermediate rolling, and finish rolling. Compact the bituminous material until the surface is tightly bound and shows no displacement under operation of the roller.

For patching, immediately after spreading perform initial rolling with pneumatic-tired rollers or combination rollers.

b. Breakdown Rolling.
Pass a roller over the placement area one or more times. Use a roller from the following list:

- Self-Propelled Pneumatic-Tired Roller;
- Smooth-Faced Steel-Wheel Roller: Tandem – Type A;
- Vibratory Roller; or
- Combination Rollers.

c. Intermediate Rolling.
Perform intermediate rolling following breakdown rolling using a self-propelled pneumatic-tired roller or a combination roller until the surface is tightly bound and shows no displacement under the roller.

If roller tires pick up the bituminous material or there are excessive roller marks in the mat, the Engineer may allow the removal of the intermediate rolling operation if it appears to the Engineer that compaction is being achieved.

d. Finish Rolling.
Perform finish rolling with a tandem Type B smooth-faced steel-wheel roller or a vibratory roller in the static mode. Continue finish rolling until roller marks are eliminated.

J. Joints.

1. General.
Place pavement against the surface of curbing, gutters, manholes, and similar structures uniformly near the contact surfaces so the pavement is slightly higher than the edge of the structure after compaction.

Do not construct a joint on top of a joint from a previous lift or in a wheel path.

2. **Longitudinal Joints.**
Construct longitudinal joints within 6 inches of the pavement marking lane lines.

Place and follow markings to guide the paver. Construct joints in a uniform line. Correct pavement edges that deviate from the uniform line and correct areas of the joint that vary from the intended location of the joint by more than 2 inches. Construct joints with tight seams and no visible segregation.

3. **Transverse Joints.**
Construct transverse joints on successive lifts a minimum of 12 feet from the previous transverse joint.

K. Tolerances.
Correct surface irregularities that exceed 3/16 inch measured with a 16 foot straightedge.

L. Pavement Sloughs.
Compact pavement sloughs with rollers capable of providing a smooth finished compacted slough that is free of tire marks and unevenness and drop-offs. The Engineer will not require density tests.

M. Acceptance.

1. **General.**
The Engineer will accept bituminous mix based on the criteria in this section.

The Engineer will include material used in shoulder placement when calculating the total quantity of material affected by the Aggregate and Asphalt Content pay factors. The Engineer will exclude materials used in shoulder placement when calculating the Field Density and will not designate core locations within shoulder areas.

2. **Aggregate.**
The Engineer will accept aggregate used in the mix based on QC tests that are verified by QA testing, and the control limits specified in Construction Requirements E.5, “Control Limits”.

If the results for two consecutive aggregate gradation tests in a single day fall outside the single test target value control limits, the Engineer will apply a contract price adjustment as specified in Basis of Payment C, “Contract Price Adjustments”.

3. **Asphalt Content.**
The Engineer will base the acceptance of the asphalt content of bituminous mix on the totalizer readings obtained as specified in Construction Requirements E, “QC Testing” and SFN 9988, “Mix Bitumen Cut-Off Report” and will apply a contract price adjustment as specified in Basis of Payment C, “Contract Price Adjustments”.

If the average asphalt content, as determined by the Engineer according to SFN 9988, “Mix Bitumen Cut-off Report” deviates from the target value by 0.40 percentage points or more, the Engineer may reject the material. If the material is accepted, the Engineer will

apply a contract price adjustment as specified in Basis of Payment C, “Contract Price Adjustments”.

4. **Field Density.**
This section will apply when the pavement is constructed as specified in Construction Requirements I.2, “Calculated Density”.

The Engineer will base acceptance of the density of hot mix asphalt on the average density of the pavement compared to the daily average maximum theoretical density. The comparison will be made using SFN 59132, “Density Pay Factor”.

The Engineer will determine the density of pavement based on lots. A lot is equal to the amount of material, in tons, placed each production day.

A sublot is defined as a single lift, one paver width wide, and 1,000 feet long. If a partial sublot is less than 500 feet, it will be included in the previous sublot. A partial sublot 500 feet or greater will be considered a separate sublot.

The individual sublot densities will be averaged to determine the density of the pavement lot.

If the average density of the pavement compared to the daily average maximum theoretical density is above the values in Table 10, the Engineer will apply the adjustment factors specified in Basis of Payment C, “Contract Price Adjustments”.

If the average density of the pavement compared to the daily average maximum theoretical density is at or below 89.0% remove and replace the pavement.

METHOD OF MEASUREMENT

The Engineer will measure, completed and in place, as specified in Section 109.01, “Measurement of Quantities” and the following:

A. Bituminous Pavement.
The Engineer will pay for the tonnage of bituminous mix used in the accepted pavement and will make no deduction for the weight of asphalt cement used in the mixture.

B. Asphalt Cement.
The Engineer will determine the quantity of asphalt cement used each day by completing SFN 9988, “Mix Bitumen Cutoff Report”.

C. Cored Sample.
The Engineer will measure each individual cored sample that is removed in the required condition.

D. Tack.
Tack will be measured as specified in Section 401.05, “Method of Measurement”.

BASIS OF PAYMENT

A. General.

Pay Item	Pay Unit
__Asphalt Cement	Ton or Gallon
Superpave, FAA 43 – 4.75 MM	Ton
Superpave, FAA 45 – 9.0 MM	Ton
Cored Sample	Each

Such payment is full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

B. Tack.

Tack will be paid for as specified in Section 401.06, “Basis of Payment”.

C. Contract Price Adjustments.

1. General

The Engineer will calculate the Combined Adjustment Factor by multiplying the individual adjustment factors for:

- Aggregate gradation;
- Asphalt content; and
- Compaction.

1.0 will be subtracted from the Combined Adjustment Factor to determine the Contract Price Adjustment.

The contract price adjustment will be determined by multiplying the Contract Price Adjustment Factor by the total tons of hot mix asphalt placed during a single day and the contract unit price for “Superpave, FAA __” or “RAP Superpave FAA ___”.

2. Aggregate Gradation Adjustment Factor.

The aggregate gradation adjustment factor will only be applied if two consecutive aggregate gradation tests in a single day contain a sieve that is outside the Single Test Target Value Control limits specified in Table 07. If different sieves fall outside the limits on consecutive tests, the adjustment factor will be applied.

If more than one sieve exceeds the Single Test Value Control Limits, the Engineer will use the largest uniformity deviation (U) when determining the adjustment factor.

When the aggregate gradation factor is applied, the Engineer will calculate the adjustment factor using the largest deviation (U) to calculate the adjustment factor.

$$Adjustment\ Factor = \frac{100 - U}{100}$$

3. Asphalt Content Adjustment Factor.

For each day’s production, the Engineer will apply the lowest adjustment factor determined from the average or uniformity methods.

a. Average.
The Engineer will determine average asphalt content using SFN 9988, "Mix Bitumen Cut-off Report" and apply the appropriate adjustment factor specified in Table 10.

If the average asphalt content deviates from the mix design by 0.40 percentage points or more, the Engineer will determine the adjustment factor in accordance with Section 105.07, "Conformance with the Contract Requirements", or may reject the material.

Table 10
Average Asphalt Content

Deviation from Target (percentage points)	Adjustment Factor
0.00-0.24	1.00
0.25-0.29	0.98
0.30-0.34	0.95
0.35-0.39	0.92
≥ 0.40	Section 105.07

b. Uniformity.
The Engineer will determine the average asphalt cement content based on the totalizer readings specified in Construction Requirements E, "QC Testing" and SFN 18674, "Asphalt Content & Virgin Aggregate Determination Report".

If the asphalt content from any random reading varies from the daily average of the readings by more than 0.24 percentage points, the Engineer will calculate the adjustment factor according to SFN 18552 "Daily Report – Hot Bituminous Pavement – Quality Control".

$$Adjustment\ Factor = \frac{100 - [20(Deviation - 0.24)]}{100}$$

4. Compaction Adjustment Factor.
The adjustment factor for compaction will not be used for areas constructed according to Construction Requirements I.3, "Ordinary Compaction".

The Engineer will apply the appropriate adjustment factor specified in Table 11.

Table 11
Adjustment Factors for FAA 45 – 9.0 MM

Adjustment Factor	Avg. Pavement Density
1.03	≥ 93.6%
1.02	93.1% - 93.5%
1.00	92.0% - 93.0%
0.98	91.0% - 91.9%
0.95	90.5% - 90.9%
0.91	90.0% - 90.4%
0.85	89.5% - 89.9%
0.70	89.0% - 89.4%

D. Bitumen Testing Price Adjustment.

The Engineer will apply Bitumen Testing Price Adjustment to each individual sublot of material. If more than one test parameter in a sublot results in a pay factor of less than 1.00, the Engineer will apply the pay factor that results in the largest monetary deduction to that sublot.

The pay factor determined by the Engineer will be applied to the "PG _____ Asphalt Cement" contract item. The pay factor will be multiplied by the unit cost of the item and the quantity of oil represented by the sample.

Table 12
Requirements on Original Binder

Specification	Test Result	Pay Factor (Percent)
Dynamic Shear AASHTO T 315 G*/sin δ Min. 1.00 kPa	≥ 1.00	1.00
	0.97 – 0.99	0.95
	0.94 – 0.96	0.90
	0.91 – 0.93	0.85
	< 0.91	0.70

Table 13
Requirements on Rolling Thin Film Oven (RTFO) Residue

Specification	Test Result	Pay Factor (Percent)	Specification	Test Result	Pay Factor (Percent)
Heavy Traffic "H" AASHTO T 350 $J_{nr@3.2}$ Max. 2.0 kPa^{-1}	≤ 2.0	1.00	Heavy Traffic "H" AASHTO R 92 Percent Recovery @ 3.2 kPa Min. 30%	> 30	1.00
	2.1	0.95		29	0.95
	2.2	0.90		28	0.90
	2.3	0.85		27	0.85
	> 2.3	0.70		< 27	0.70

Table 14
Requirements for Pressure Aging Vessel (PAV) Residue

Specification	Test Result	Pay Factor (Percent)
Traffic “H”, “V”, “E” AASHTO T 315 DSR, G*(sin δ) Max. 6000 kPa	≤ 6000	1.00
	6001 - 6050	0.95
	6051 - 6100	0.90
	6101 - 6150	0.85
	> 6150	0.70
Creep Stiffness AASHTO T 313 Max. 300 mPa	≤ 300	1.00
	301 - 310	0.95
	311 - 320	0.90
	321 - 330	0.85
	> 330	0.70
m-value AASHTO T 313 Min. 0.300	≥ 0.300	1.00
	0.295 – 0.299	0.95
	0.290 – 0.294	0.90
	0.285 – 0.289	0.85
	< 0.285	0.70

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

THINLAY

PROJECT 1-804(050)072 – PCN 23223

DESCRIPTION

This work consists of constructing a thin HMA overlay

Sample and test as outlined in the Field Sampling and Testing Manual

EQUIPMENT

A. General.

Equipment	Section
Self-Propelled Pneumatic-Tired Roller	151.01 C
Smooth-Faced Steel-Wheel Roller: Tandem – Type A	151.03 A.2
Smooth-Faced Steel-Wheel Roller: Tandem – Type B	151.03 A.3
Vibratory Roller	151.03 B
Combination Roller	151.04
Bituminous Trucks	152.01 D
Bituminous Tank Trucks	152.01 E
Bituminous Equipment	154

When air temperatures fall below 50˚ F at any place along the haul route of the mix, deploy the tarps installed on the bituminous trucks.

B. Paver.

Provide a paver that meets the requirements of Section 154.02 A, “Pavers”. When using the 4.75 mm mixture, supply a paver that meets the requirements of Section 154.02 A, “Pavers” with the following modification:

Supply a paver that is equipped with integrated spray bars in front of the screed for applying tack coat immediately before the asphalt is laid.

MATERIALS

A. General.

Item	Section
Bituminous Material	818

B. Asphalt Cement.

The Engineer will accept asphalt cement as outlined in the Combined State Binder Group agreement for North Dakota. The Contractor shall obtain samples of this material under the observation of the Engineer. The Engineer will take immediate possession of the samples.

C. Aggregate.

Develop a mix design that contains an aggregate gradation that conforms to the requirements in Table 01.

Table 01
Aggregate Gradation for Mix Design

Sieve Size	Superpave – 9.5 mm		Superpave – 4.75 mm	
	Min	Max	Min	Max
½ Inch	100	100		
3/8 Inch	97	100	100	100
#4		90	90	100
#8	32	67		90
#16			30	55
#30	15	35	15	35
#200	2.0	10.0	2.0	10.0

Provide aggregate that meets the requirements in Table 02.

Table 02

Test Designation	Test Name	Criteria
ND T 176	Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test	40% minimum
ND D 4791	Test Method for Flat Particles, Elongated Particles, or Flat Elongated Particles in Coarse Aggregate	10% maximum
AASHTO T 96	Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine	40% maximum
ND T 113	Lightweight Pieces in Virgin Aggregate	5.0% maximum

D. Superpave Mix Properties.

Provide mix that meets the requirements of Table 03. Base the fine aggregate angularity (FAA) on the designation of the bid item.

Table 03

Property	FAA 43	FAA 45
Fractured Particles in Coarse Aggregate (minimum)	75%	85%
Fine Aggregate Angularity (minimum)	43%	45%

Table 03		
Property	**FAA 43**	**FAA 45**
Gyratory Effort, # of Gyrations	N_{ini} = 7, N_{des} = 75, N_{max} = 115	N_{ini} = 7, N_{des} = 75, N_{max} = 115
Voids filled with Bitumen	65-78%	65-75%
$\%G_{mm}$ @ N_{ini} (maximum)	89%	89%

The superpave mix properties shown in Table 03 will be determined according to the methods shown in Table 04.

Table 04
Methods for Determining Superpave Mix Properties

Fractured Particles in Coarse Aggregate	NDDOT 4
Fine Aggregate Angularity	ND T 304
Gyratory Effort, # of Gyrations	AASHTO R 35
Voids filled with Bitumen	AASHTO M 323, ND T 166
$\%G_{mm}$ @ N_{ini}	AASHTO M 323, ND T 166

E. Preparation of Aggregates.
When using a drum-dryer mixer, prepare aggregate so that the moisture content of the bituminous mixture is less than 1 percent.

Screen aggregates used in a cold-feed control into two or more fractions consisting of at least 1 fine and 1 coarse aggregate stockpile. Feed aggregate from the stockpile into separate compartments for accurate proportioning into the mixer.

CONSTRUCTION REQUIREMENTS

A. Contractor Quality Control (QC).

1. Quality Control Personnel.
Provide the following personnel:
- Certified Aggregate Field Lab Tester to be on the project during aggregate production;
- Certified Aggregate Field Lab and Asphalt Mix Tester to be on the project during asphalt mix production;
- Certified Asphalt Pavement Inspector to be on the project during paving operations; and
- Certified Asphalt Mix Controller to be on the project during paving operations.

Ensure that all personnel performing tests on materials used in the paving operation are certified as outlined in the Department's Technical Certification Program (TCP). The requirements of the TCP can be found on the Department's website, www.dot.nd.gov.

2. Quality Control Plan.
Before beginning work, submit a copy of the QC plan to the Engineer. Provide and maintain copies of the plan at the Quality Assurance (QA) and QC laboratories. Provide the following minimum information in the plan:

a. The names and phone numbers of the individuals responsible for the QC program.
b. A listing of the personnel responsible for the QC testing and their Technician ID and qualifications.
c. An organizational chart indicating lines of authority, including names and phone numbers.
d. Details of the QC plan addressing the following items:
   - Pit operations and methods used to control uniformity, limiting segregation, and efficiently utilizing the aggregate resources of the pit;
   - Plant operations listing proposed equipment and method of operations;
   - Site plan drawing of plant;
   - Testing frequency for both aggregate production and mix production; and
   - Discussion of how the QC program responds to the need for corrective action.

An example quality control plan is available on the Department's website.

B. Engineer's Quality Assurance Plan.
The Engineer will provide a quality assurance plan to the Contractor at the time the Contractor submits the quality control plan specified in Construction Requirements A.2, "Quality Control Plan." The quality assurance plan will contain:

- The names and phone numbers of the individuals responsible for the QA program.
- A listing of the personnel responsible for the QA testing and their Technician ID and qualifications.
- An organizational chart indicating lines of authority, including names and phone numbers.

C. Pit Operations and Stockpiling of Aggregate.

1. General.
Perform the tests required in Section 430.02 A.2, "Contractor Testing" in the Field Sampling and Testing Manual. Provide copies of test results for each stockpile of aggregate by noon the day following the tests.

Before the start of bituminous mix production, stockpile 50 percent of the required quantity of bituminous mixture at the plant.

During bituminous mix production, maintain 25 percent of the required quantity of bituminous mixture to finish production.

2. Determination of Specific Gravity.
If the specific gravity values determined by the Contractor and Engineer as required by Section 430.02, "Quality Control Testing" of the Field Sampling and Testing Manual correlate within 0.040, proceed with developing a mix design using the Contractor's averaged specific gravity values.

If the specific gravity values determined by the Contractor and Engineer as required by Section 430.02, “Quality Control Testing” of the Field Sampling and Testing Manual do not correlate within 0.040, choose one of the following options:

- Perform the tests together with the Engineer at an agreed upon location; or
- Resolve the testing differences according to the dispute resolution procedures in Section 430.04, “Dispute Resolution” of the Field Sampling and Testing Manual.

Once resolved, proceed with the development of a mix design using the determined number for the tests performed with the Engineer or the number determined by the dispute resolution procedure.

D. Mix Design.

1. General.

Develop the mix design according to NDDOT 2. Use the Department mix design spread sheet available at www.dot.nd.gov. Do not begin production of hot bituminous pavement before the Department approves the mix design.

If the project will contain both recycled and non-recycled pavements, submit one mix design containing recycled material and one without recycyled material.

Submit the mix design a minimum of 10 calendar days before beginning paving operations. The Engineer will review the mix design. If the Engineer does not approve the mix design, revise the mix design and submit the revised mix design. Allow 10 calendar days for the Engineer to review a revised mix design before beginning paving operations.

When making the blend determinations for the mix design, use the average of the production samples value for each sieve from each stockpile.

Base the mix design on the criteria specified in Table 05 and develop the mix design according to the standards outlined in Table 06.

TABLE 05
Hot Mix Asphalt Testing Criteria

Procedure/Property /Test	Superpave – 9.5 mm	Superpave – 4.75 mm	Reference
Voids in Mineral Aggregate	15.0 Min	16.0 Min	AASHTO M 323 ND T 166
% G_{mm} @ N_{max}	98.0 Max	98.0 Max	AASHTO M 323 ND T 166
Dust/Effective Asphalt Ratio	0.8 – 1.6	1.0 – 2.0	AASHTO M 323 ND T 166
Asphalt Film Thickness [1] (Microns)	7.5 - 13	7.5 - 13	Determined by Department’s mix design program.

TABLE 06
AASHTO SUPERPAVE MIX DESIGN STANDARDS

Designation	Title
ND T 312	Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
AASHTO R 35	Practice for Superpave Volumetric Design for Hot Mix Asphalt
AASHTO R 30	Mix Conditioning of Hot Mix Asphalt (HMA)
AASHTO M 323	Specification for Superpave Volumetric Mix Design
ND T 166	Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens

Submit a revised mix design if:

- utilizing aggregate from sources not initially submitted;
- processing the aggregate using a different crusher; or
- using a different type or grade of bitumen.

Allow 10 calender days for the Department to review the revised mix design before incorporating the material into the work.

If the source of bitumen changes from the approved mix design, immediately notify the Engineer of the change and provide the relevant information related to the new source. The Engineer may request a new mix design. If the Engineer requests a new mix design, submit the necessary materials and allow 10 days for the Department to review the revised mix design before incorporating the material into the work.

2. Items to be Submitted.

Submit the following items with each mix design:

a. An aggregate sample representing each stockpile used for the mix design. The total weight of material shall be approximately 150 lbs.

b. Eight one-quart cans of PG asphalt. The PG asphalt shall be the same grade specified on the plans and from the supplier that will be used on the project.

When multiple grades of PG asphalt are specified, one grade may be supplied, but it must be the same grade used to develop the mix design.

c. Approximately 30 lbs of loose asphaltic concrete mix prepared at the optimum asphalt content recommended by the mix design.

d. The Contractor shall submit a mix design that contains the following elements:

1. The percentage of aggregate passing each of the specified sieves.
2. The percent asphalt cement to be added to the mixture.
3. The target air voids will be 3.0%.
4. The maximum specific gravity of the mixture obtained in the laboratory.
5. The bulk specific gravity of the mixture obtained in the laboratory.
6. The percent VMA of the mixture obtained in the laboratory.
7. Calculated film thickness (microns).
8. Calculated dust/asphalt ratio.

9. %Gmm @ Nini
10. %Gmm @ Nmax

E. QC Testing.

1. General.

During production of the bituminous mix, perform sampling and testing on the aggregate and bituminous mix as the mix is being produced and placed on the roadway.

Perform the tests specified in Section 430.02, “Quality Control Testing” of the Field Sampling and Testing Manual at the designated frequencies. During aggregate production, test results must be made available by noon the day following the test. During mix production, furnish copies of test results upon completion of the test.

If the QC test results for ND T 176 or ND T 113 indicate uniform results, the Engineer may issue a written notice reducing the frequency of these tests.

2. Determination of Asphalt Content.

Under the observation of the Engineer, determine the asphalt content each time a gradation test is taken. Base the asphalt content on readings from the totalizers for the aggregate and the asphalt as outlined in SFN 18674, “Asphalt Content & Virgin Aggregate Determination”.

3. Sample Splitting.

The Engineer will take possession of one half of the split QC sample and will perform testing on a portion of the material, as necessary.

The portion of the sample submitted to the Engineer will be retained for 24 hours after the QA test representing the lot of material has been performed. Either the Engineer or Contractor may request to have the remaining portion of the sample tested within the 24 hour timeframe. If a request is made, the Engineer will test the remaining portion of the QC sample and the Engineer’s results will be used as the basis for acceptance of the aggregate.

4. Documentation.

Maintain complete records of all process quality control tests. Record all test results and calculations and document results on Department provided forms. The required forms are available on the Department’s website www.dot.nd.gov. The proper forms for individual tests are listed in the Field Sampling and Testing Manual.

Maintain control charts at the QC laboratory. Record test results on the control charts immediately upon completion of the test. Record the following parameters on the control charts:

- Gradation of the control sieves (1/2 Inch, #4, #30, and #200), (ND T 27 and ND T 11);
- Asphalt Content;
- Theoretical Maximum Specific Gravity, (ND T 209);
- Bulk Specific Gravity, (ND T 166);
- Percent Air Voids of field Gyratory samples;
- Daily average Air Voids percentage of the cores;

- Average Daily Density;
- Fines/Asphalt Ratio;
- Asphalt Film Thickness (microns); and
- Fine Aggregate Angularity.

Control charts must display:

- Single test control limits for each test parameter;
- Individual test results;
- Moving average control limits; and
- Moving average of the last four tests.

Color code the moving average results and control limits, and the single tests and control limits.

Make the control charts available at the QC laboratory and accessible for review by the Engineer during the paving operations. Submit complete control charts upon completion of the paving operations.

5. Control Limits.

The field test results may vary from the mix design target values as shown in Table 07.

TABLE 07
ALLOWABLE WORKING RANGES

Test/Assessment		Single Test Target Value Control Limit	Moving Average Target Value Control Limit
Asphalt Content (based on totalizer reading)		±0.30	±0.24
ND T 11 and ND T 27 and	Sieve Analysis of Fine and Coarse Aggregates (Control Sieves)		
	1/2"	±6.0	±5.0
	3/8 “	±6.0	±5.0
	#4 Sieve	±6.0	±5.0
	# 8 Sieve	±5.0	±4.0
	#16 Sieve	±5.0	±4.0
	#30 Sieve	±5.0	±4.0
	#200 Sieve[1]	±2.0	±1.5
SFN 50289	Percent Air Voids	1.5% - 5.0%	2.0% - 4.5%
	VMA	-0.5	-0.5
ND T 113	Lightweight Pieces in Aggregate	Not more than the maximum specified	
NDDOT 4	Percentage of Fracture Particles in Coarse Aggregate	Not less than the minimum specified	
ND T 304	Fine Aggregate Angularity	Not less than the minimum specified	

TABLE 07
ALLOWABLE WORKING RANGES

Test/Assessment		Single Test Target Value Control Limit	Moving Average Target Value Control Limit
ND D 4791	Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate	Not more than the maximum specified	
ND T 176	Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test	Not less than the minimum specified	

[1] Not to exceed the maximum specified in Table 01.

a. Single Test Target Values.
If an individual test falls outside the single test target value control limits, take immediate corrective action. After implementation of the corrective action, collect a sample and conduct the test that fell outside the control limits. If the test following the corrective action falls outside of the control limits discontinue paving operations until the cause is found and corrected. Resume paving operations only after obtaining approval from the Engineer.

The test following the corrective action is used to determine the effectiveness of the corrective action. It is not used for acceptance of material and will not be factored into the moving average.

If, in an individual gradation test, a single control sieve falls outside the single test target value control limits, continued production is allowed only if the air voids are within the control limits and the material passing the #200 sieve does not exceed the maximum specified in Table 01.

Discontinue paving operations if 2 consecutive tests exceed the single test target value control limit for any of the following:

- ND T 113, Lightweight Pieces in Aggregate;
- ND T 304, Fine Aggregate Angularity;
- NDDOT 4, Percentage of Fracture Particles in Coarse Aggregate; or
- ND T 176, Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test.

Resume paving operations only after taking corrective action and obtaining approval from the Engineer.

b. Moving Average Target Values.
The moving average for each test is determined using the 4 most recent test results.

If the moving average for a test trends toward the moving average target value control limits, take corrective action. After implementation of the corrective action collect a sample and conduct the test that is trending towards the moving average control limits. The test following the corrective action is used to determine the effectiveness of the

corrective action. It is not used for acceptance of material and will not be factored into the moving average. Document the corrective action.

If the moving average for a test exceeds the moving average target value control limits, continued production is allowed only if the air voids are within the control limits and the material passing the #200 sieve does not exceed the maximum specified in Table 01.

If the air voids are outside the control limits or the material passing the #200 sieve exceeds the maximum specified in Table 01, perform one of the following actions:

- Implement corrective measures to produce mix that is based on the mix design; or
- Request that new target values be set if the test results indicate that adjustments to the target values are necessary. Implement the adjusted target values only after receiving the Engineer's written approval.

If the moving average for air voids exceeds the moving average control limit, discontinue paving operations and implement corrective measures. The Engineer may allow continued paving if satisfied with the corrective measures. Resume quality control testing when the plant has started and operations are equalized.

F. Surface Preparation.

Remove deleterious material from the surface.

Correct local irregularities in the existing surface before placing the first lift of bituminous material. If milling is specified, correct local irregularities after milling. Apply a tack coat to the surface before correcting the irregularities. Use the same type of mix that is required for the subsequent lift. Use self-propelled pneumatic-tired rollers to roll and compact the mix.

The mix required for correcting local irregularities will be deducted from the total mix used for the project, meaning that the subsequent lift of pavement will be thinner than originally planned.

Apply a tack coat to the surface and to the exposed edges of longitudinal and transverse joints before placing bituminous pavement. Apply a double application of tack coat to longitudinal joints and a minimum of one inch on either side of the joint. Apply a tack coat on a previously placed layer or surface of pavement before placing the next lift.

G. Patching.

Remove existing broken or unstable surface material and replace that material with the same mixture specified for the next course.

Place the bituminous material in lifts not to exceed 3 inches and compact the material. Allow the patch material to cool to 130°F before placing additional material. If patching is required during the paving operation allow the patch material to cool to 185°F before placing additional material.

H. Spreading and Finishing.

1. General.

Do not place bituminous mixture on a damp pavement surface or when weather conditions prevent the proper handling and finishing of the bituminous mixtures.

Use bituminous pavers to spread and finish mixtures to the required section leaving the mixture uniformly dense, smooth, and free from irregularities. In locations where it is impractical to use normal laydown equipment the Engineer will allow other methods.

Supply mix that is uniform and homogeneous. The Engineer will reject loads of mix or sections of pavement containing uncoated batches of aggregate or segregated materials.

Remove and replace material that is visibly segregated. If a paver placed the material, remove the segregated material to the full width of the paver. If the material was placed by hand, remove the full area of segregated material, plus an additional 6 inches around the entire segregated area.

Place bituminous mixture so a single lane is not more than one day's run in advance of any adjacent lane. Leveling courses are excluded from this requirement.

Do not place bituminous pavement on bridge decks.

2. Air and Surface Temperature Requirements.

Place bituminous mix without supplementary admixture when the temperatures are at or above the requirements in Table 08. Include a supplementary admixture such as Evotherm, AD-here LOF 65-00 EU, or an approved equal in the bituminous mixture when placing bituminous mix when temperatures are within the ranges shown in Table 09. Do not place bituminous mix when temperatures are below those shown in Table 09.

Table 08
Standard Paving Temperatures

Compacted Thickness	Air Temp for Surface Course	Air Temp for Subsurface Course and Approaches	Existing Mat
1-1/2 inches or less	45°F	40°F	40°F

If placing bituminous mix according to Table 09, submit the supplementary admixture manufacturer's dosage rate and any changes to the mix design. The supplementary admixture may be added to the asphalt binder by the supplier or refiner, or by the Contractor at the asphalt plant. Add the admixture to the binder according to the supplementary admixture manufacturer's recommendations. If the admixture is added at the plant, equip the plant with a metering device that records the rate of admixture. Tie the metering device into the same system that measures the other components of the mix.

Table 09
Paving Temperatures Using Supplementary Admixtures

Compacted Thickness	Air Temp for Surface Course	Air Temp for Subsurface Course and Approaches	Existing Mat
1-1/2 inches or less	40°F - 45°F	35°F - 40°F	35°F - 40°F

Measure the existing mat temperature using one of the following methods:

- Using an infrared sensing thermometer; or

- Insert a conventional thermometer into a 1 inch deep hole in the pavement. Fill the hole with water, oil, or grease.

3. Mix Temperature Requirements.
Discharge mix from the mixer with a temperature no higher than the bituminous material manufacturer's recommendation. If there are no recommendations on maximum mix temperature, discharge mix with a maximum temperature of 300°F.

When the ambient temperature is 60°F or higher, place mix with a minimum laydown temperature of 240°F. When the temperature is below 60°F, place mix with a minimum laydown temperature of 260°F.

I. Compaction.

1. General.
Remove all surface irregularities before beginning compaction.

Sequence rolling operations and select the type and the number of rollers to match production and to attain the required density before the mat temperatures fall below 185°F.

In areas not accessible to rollers, compact the pavement mat with hand or mechanical tampers.

2. Calculated Density.

a. General.
Use calculated density on mainline pavement, interstate crossroads, ramps, turn lanes, rest area approaches, and parking lots.

Calculated density will not apply to the 4.75 MM HMA mix.

b. Coring.

(1) General.
Obtain pavement cores at locations designated by the Engineer under the observation of the Engineer.

Use a machine that cuts a cylindrical core sample without disturbing the density of the sample. Complete coring on or before the working day following the placement of the lift. Obtain a core with a smooth outer surface, no distortion of the cylindrical shape, and no displacement of the aggregate particles. Obtain a core that is 4 to 6 inches in diameter and the full depth of the in place asphalt.

Fill core holes before placing the subsequent lift of pavement. If there is no subsequent lift of pavement, fill the core hole within 24 hours of obtaining the core. Remove free standing water before filling core holes. Fill core holes in 2 inch lifts using material from the same mix design used on the roadway. Compact each lift using a hand tamper.

(2) Pavement Density Cores.
Use a masonry saw to cut the core so that only the layer to be tested is removed.

Label each core, using a system approved by the Engineer, to identify the location from which the core was obtained.

(3) Pavement Thickness Determination Cores.
Obtain pavement thickness determination cores after the final lift of pavement has been placed. Label the cores. The Engineer will take possession of these cores immediately upon extraction. Do not cut these cores.

3. Ordinary Compaction.

a. General.
Use ordinary compaction on FAA 43 – 4.75 MM HMA as well as on shoulders, driveways, section line approaches, bike paths, leveling courses, and patches.

Ordinary compaction consists of breakdown rolling, intermediate rolling, and finish rolling. Compact the bituminous material until the surface is tightly bound and shows no displacement under operation of the roller.

For patching, immediately after spreading perform initial rolling with pneumatic-tired rollers or combination rollers.

b. Breakdown Rolling.
Pass a roller over the placement area one or more times. Use a roller from the following list:

- Self-Propelled Pneumatic-Tired Roller;
- Smooth-Faced Steel-Wheel Roller: Tandem – Type A;
- Vibratory Roller; or
- Combination Rollers.

c. Intermediate Rolling.
Perform intermediate rolling following breakdown rolling using a self-propelled pneumatic-tired roller or a combination roller until the surface is tightly bound and shows no displacement under the roller.

If roller tires pick up the bituminous material or there are excessive roller marks in the mat, the Engineer may allow the removal of the intermediate rolling operation if it appears to the Engineer that compaction is being achieved.

d. Finish Rolling.
Perform finish rolling with a tandem Type B smooth-faced steel-wheel roller or a vibratory roller in the static mode. Continue finish rolling until roller marks are eliminated.

J. Joints.

1. General.
Place pavement against the surface of curbing, gutters, manholes, and similar structures uniformly near the contact surfaces so the pavement is slightly higher than the edge of the structure after compaction.

Do not construct a joint on top of a joint from a previous lift or in a wheel path.

2. **Longitudinal Joints.**
Construct longitudinal joints within 6 inches of the pavement marking lane lines.

Place and follow markings to guide the paver. Construct joints in a uniform line. Correct pavement edges that deviate from the uniform line and correct areas of the joint that vary from the intended location of the joint by more than 2 inches. Construct joints with tight seams and no visible segregation.

3. **Transverse Joints.**
Construct transverse joints on successive lifts a minimum of 12 feet from the previous transverse joint.

K. Tolerances.
Correct surface irregularities that exceed 3/16 inch measured with a 16 foot straightedge.

L. Pavement Sloughs.
Compact pavement sloughs with rollers capable of providing a smooth finished compacted slough that is free of tire marks and unevenness and drop-offs. The Engineer will not require density tests.

M. Acceptance.

1. **General.**
The Engineer will accept bituminous mix based on the criteria in this section.

The Engineer will include material used in shoulder placement when calculating the total quantity of material affected by the Aggregate and Asphalt Content pay factors. The Engineer will exclude materials used in shoulder placement when calculating the Field Density and will not designate core locations within shoulder areas.

2. **Aggregate.**
The Engineer will accept aggregate used in the mix based on QC tests that are verified by QA testing, and the control limits specified in Construction Requirements E.5, “Control Limits”.

If the results for two consecutive aggregate gradation tests in a single day fall outside the single test target value control limits, the Engineer will apply a contract price adjustment as specified in Basis of Payment C, “Contract Price Adjustments”.

3. **Asphalt Content.**
The Engineer will base the acceptance of the asphalt content of bituminous mix on the totalizer readings obtained as specified in Construction Requirements E, “QC Testing” and SFN 9988, “Mix Bitumen Cut-Off Report” and will apply a contract price adjustment as specified in Basis of Payment C, “Contract Price Adjustments”.

If the average asphalt content, as determined by the Engineer according to SFN 9988, “Mix Bitumen Cut-off Report” deviates from the target value by 0.40 percentage points or more, the Engineer may reject the material. If the material is accepted, the Engineer will

apply a contract price adjustment as specified in Basis of Payment C, “Contract Price Adjustments”.

4. **Field Density.**
This section will apply when the pavement is constructed as specified in Construction Requirements I.2, “Calculated Density”.

The Engineer will base acceptance of the density of hot mix asphalt on the average density of the pavement compared to the daily average maximum theoretical density. The comparison will be made using SFN 59132, “Density Pay Factor”.

The Engineer will determine the density of pavement based on lots. A lot is equal to the amount of material, in tons, placed each production day.

A sublot is defined as a single lift, one paver width wide, and 1,000 feet long. If a partial sublot is less than 500 feet, it will be included in the previous sublot. A partial sublot 500 feet or greater will be considered a separate sublot.

The individual sublot densities will be averaged to determine the density of the pavement lot.

If the average density of the pavement compared to the daily average maximum theoretical density is above the values in Table 10, the Engineer will apply the adjustment factors specified in Basis of Payment C, “Contract Price Adjustments”.

If the average density of the pavement compared to the daily average maximum theoretical density is at or below 89.0% remove and replace the pavement.

METHOD OF MEASUREMENT

The Engineer will measure, completed and in place, as specified in Section 109.01, “Measurement of Quantities” and the following:

A. Bituminous Pavement.
The Engineer will pay for the tonnage of bituminous mix used in the accepted pavement and will make no deduction for the weight of asphalt cement used in the mixture.

B. Asphalt Cement.
The Engineer will determine the quantity of asphalt cement used each day by completing SFN 9988, “Mix Bitumen Cutoff Report”.

C. Cored Sample.
The Engineer will measure each individual cored sample that is removed in the required condition.

D. Tack.
Tack will be measured as specified in Section 401.05, “Method of Measurement”.

BASIS OF PAYMENT

A. General.

Pay Item	Pay Unit
__Asphalt Cement	Ton or Gallon
Superpave, FAA 43 – 4.75 MM	Ton
Superpave, FAA 45 – 9.0 MM	Ton
Cored Sample	Each

Such payment is full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

B. Tack.
Tack will be paid for as specified in Section 401.06, “Basis of Payment”.

C. Contract Price Adjustments.

1. General
The Engineer will calculate the Combined Adjustment Factor by multiplying the individual adjustment factors for:

- Aggregate gradation;
- Asphalt content; and
- Compaction.

1.0 will be subtracted from the Combined Adjustment Factor to determine the Contract Price Adjustment.

The contract price adjustment will be determined by multiplying the Contract Price Adjustment Factor by the total tons of hot mix asphalt placed during a single day and the contract unit price for “Superpave, FAA __” or “RAP Superpave FAA ___”.

2. Aggregate Gradation Adjustment Factor.
The aggregate gradation adjustment factor will only be applied if two consecutive aggregate gradation tests in a single day contain a sieve that is outside the Single Test Target Value Control limits specified in Table 07. If different sieves fall outside the limits on consecutive tests, the adjustment factor will be applied.

If more than one sieve exceeds the Single Test Value Control Limits, the Engineer will use the largest uniformity deviation (U) when determining the adjustment factor.

When the aggregate gradation factor is applied, the Engineer will calculate the adjustment factor using the largest deviation (U) to calculate the adjustment factor.

$$Adjustment\ Factor = \frac{100 - U}{100}$$

3. Asphalt Content Adjustment Factor.
For each day’s production, the Engineer will apply the lowest adjustment factor determined from the average or uniformity methods.

a. Average.
The Engineer will determine average asphalt content using SFN 9988, "Mix Bitumen Cut-off Report" and apply the appropriate adjustment factor specified in Table 10.

If the average asphalt content deviates from the mix design by 0.40 percentage points or more, the Engineer will determine the adjustment factor in accordance with Section 105.07, "Conformance with the Contract Requirements", or may reject the material.

Table 10
Average Asphalt Content

Deviation from Target (percentage points)	Adjustment Factor
0.00-0.24	1.00
0.25-0.29	0.98
0.30-0.34	0.95
0.35-0.39	0.92
≥ 0.40	Section 105.07

b. Uniformity.
The Engineer will determine the average asphalt cement content based on the totalizer readings specified in Construction Requirements E, "QC Testing" and SFN 18674, "Asphalt Content & Virgin Aggregate Determination Report".

If the asphalt content from any random reading varies from the daily average of the readings by more than 0.24 percentage points, the Engineer will calculate the adjustment factor according to SFN 18552 "Daily Report – Hot Bituminous Pavement – Quality Control".

$$Adjustment\ Factor = \frac{100 - [20(Deviation - 0.24)]}{100}$$

4. Compaction Adjustment Factor.
The adjustment factor for compaction will not be used for areas constructed according to Construction Requirements I.3, "Ordinary Compaction".

The Engineer will apply the appropriate adjustment factor specified in Table 11.

Table 11
Adjustment Factors for FAA 45 – 9.0 MM

Adjustment Factor	Avg. Pavement Density
1.03	≥ 93.6%
1.02	93.1% - 93.5%
1.00	92.0% - 93.0%
0.98	91.0% - 91.9%
0.95	90.5% - 90.9%
0.91	90.0% - 90.4%
0.85	89.5% - 89.9%
0.70	89.0% - 89.4%

D. Bitumen Testing Price Adjustment.

The Engineer will apply Bitumen Testing Price Adjustment to each individual sublot of material. If more than one test parameter in a sublot results in a pay factor of less than 1.00, the Engineer will apply the pay factor that results in the largest monetary deduction to that sublot.

The pay factor determined by the Engineer will be applied to the "PG _____ Asphalt Cement" contract item. The pay factor will be multiplied by the unit cost of the item and the quantity of oil represented by the sample.

Table 12
Requirements on Original Binder

Specification	Test Result	Pay Factor (Percent)
Dynamic Shear AASHTO T 315 G*/sin δ Min. 1.00 kPa	≥ 1.00	1.00
	0.97 – 0.99	0.95
	0.94 – 0.96	0.90
	0.91 – 0.93	0.85
	< 0.91	0.70

Table 13
Requirements on Rolling Thin Film Oven (RTFO) Residue

Specification	Test Result	Pay Factor (Percent)	Specification	Test Result	Pay Factor (Percent)
Heavy Traffic "H" AASHTO T 350 $J_{nr@3.2}$ Max. 2.0 kPa^{-1}	≤ 2.0	1.00	Heavy Traffic "H" AASHTO R 92 Percent Recovery @ 3.2 kPa Min. 30%	> 30	1.00
	2.1	0.95		29	0.95
	2.2	0.90		28	0.90
	2.3	0.85		27	0.85
	> 2.3	0.70		< 27	0.70

Table 14
Requirements for Pressure Aging Vessel (PAV) Residue

Specification	Test Result	Pay Factor (Percent)
Traffic “H”, “V”, “E” AASHTO T 315 DSR, G*(sin δ) Max. 6000 kPa	≤ 6000	1.00
	6001 - 6050	0.95
	6051 - 6100	0.90
	6101 - 6150	0.85
	> 6150	0.70
Creep Stiffness AASHTO T 313 Max. 300 mPa	≤ 300	1.00
	301 - 310	0.95
	311 - 320	0.90
	321 - 330	0.85
	> 330	0.70
m-value AASHTO T 313 Min. 0.300	≥ 0.300	1.00
	0.295 – 0.299	0.95
	0.290 – 0.294	0.90
	0.285 – 0.289	0.85
	< 0.285	0.70

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

COMMERCIAL GRADE HOT MIX ASPHALT

PROJECT 1-804(050)072 – PCN 23223

DESCRIPTION
This work consists of supplying a Commercial Grade Hot Mix Asphalt for tying in around the new ADA ramps and curb that meets the requirements of Section 430, “Hot Mix Asphalt (HMA)”, with the following revisions.

MATERIALS
Add the following to the end of Section 430.03 “Materials”.

F. Commercial Grade Hot Mix Asphalt.
Provide commercial grade asphalt that meets the requirements of any of the FAA designations in Section 430.03 C, “Superpave Mix Properties”.

The requirements of the following sections will not be applied to commercial grade asphalt:

- Section 430.04 B, “Engineer’s Quality Assurance Plan”;
- Section 430.04 C.2, “Determination of Specific Gravity”; and
- Section 430.04 E, “QC Testing”.

Section 430.04 D “Mix Design” is replaced with the follwing requirements:

Submit a mix design that was previously approved under another Department contract. Include the project number and PCN of the previous project.

If using a stationary plant, use a mix design previously approved by the Department within the last year. Include the date that the mix design was approved.

If a previously approved mix design is not available, submit a new mix design to the Engineer at least 10 calendar days before placement of material. The Engineer will request materials to use in mix design verification before approving the mix design.

CONSTRUCTION REQUIREMENTS

A. Contractor Personnel.
Replace Section 430.04 A “Contractor Quality Control (QC) with the following:

Provide personnel meeting the requirements of NDDOT Technical Certification Program for the following tests:

- ND T 2 – Sampling of Aggregates; and
- NDDOT 5 Sampling and Splitting Field Verification of Hot Mix Asphalt (HMA) Samples.

B. Engineer's Acceptance Testing:

Replace Section 430.04 M "Acceptance" with the following:

The Engineer will perform acceptance tests at the frequency shown in Table 1. At times directed by the Engineer, obtain aggregate samples from the cold feed belt according to ND T 1.

Table 1	
Testing Frequencies	
Test/Assessment	**Minimum Testing Requirements**
ND T 11 Materials Finer than No. 200 Sieve	1 per production day.
ND T 27 Sieve Analysis of Fine and Coarse Aggregate	1 per production day
ND T 304 Fine Aggregate Angularity	1 per production day
ND T 166 Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens	1 per project
ND T 209 Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt	1 per project

The Engineer will determine the percentage of air voids when determining the maximum theoretical density. Provide mix with between 2 and 6 percent air voids, when calculated on the Maximum Density Worksheet (SFN 50289).

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Pay Item	Pay Unit
Commercial Grade Asphalt	Ton

Include the cost of aggregate, asphalt cement, prime coat, tack coat and fog coat in the contract unit price for "Commercial Grade Asphalt."

Such payment is full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.