This payment will be full compensation for all labor, equipment, and materials necessary to complete the work.

When price adjustments are required for failing material or patching, payment will be made as follows:

A. Determination of the payment adjustment of a lot of bituminous mixture will be make by successively multiplying the Contract Unit Price per Ton of the bid item by the applicable pay factors as determined in Sections 409.05 A, 409.05 B, and 409.05 C.

B. When the average of the test results specified in Section 409.05 A.2 shows a larger shale content than the maximum allowable specified, the following deduction from the Bid Price for the bituminous mixture item will be made:

   One percent reduction in unit price for each 0.2% above the maximum allowable percentage. If the percentage of shale exceeds the allowable limits by 2% or more, the material will be rejected unless the Engineer elects to accept it under Section 105.07.

   This reduction will apply to lots of 10,000 tons, and will be applied independently of Section 409.05 A.1

C. Material for patching or leveling of an existing bituminous surface constructed under a previous Contract shall be obtained from the tonnage provided in the basis of estimate and will be paid according to Section 408.07 C.

SECTION 410
HOT BITUMINOUS PAVEMENT
SUPERPAVE VOLUMETRIC MIX DESIGN

410.01 DESCRIPTION.

This work shall consist of constructing one or more courses of bituminous pavement on a prepared surface for Quality Control/Quality Assurance (QC/QA) projects. The Contractor shall be responsible for process control, and shall perform the necessary testing to control the quality of the work. When specified on the plans the contractor shall develop a mix design.

410.02 MATERIALS.

A. **Bitumen.** The bitumen shall meet Section 818 and will be of the type and grade specified in the Contract. Bitumen will be accepted as outlined in the Combined State Binder Group agreement for North Dakota. Samples will be obtained by the Contractor under the observation of the Engineer, and immediately handed over to the Engineer for shipping and testing.

B. **Aggregate.** The aggregate blend gradation will initially be based on the specifications in Table 1 and finally determined by the mix design compaction and volumetric results. A tolerance of 2% in the amount passing the 5/8-inch sieve will be permitted providing all material passes the 3/4-inch sieve.

TABLE 1
INITIAL CONTROL POINTS FOR SUPERPAVE AGGREGATE BLEND GRADATION

Sieve Size	Nominal Aggregate Size* 1/2" (12.5 mm) % Passing	
	Min.	Max.
5/8" (15.9 mm)	100	100
1/2" (12.5 mm)	90	90
#8 2.36 mm)	28	28
#200 (75 m)	2.0	2.0

*Nominal aggregate size is defined as one sieve size larger than the first sieve to retain more than 10%.

It is desired the aggregate blend not pass through an area on the 0.45 power chart called the "Restricted Zone." The boundaries of this zone are outlined in Table 2.

TABLE 2
0.45 POWER CHART RESTRICTED ZONE BOUNDARIES

Sieve Size	Nominal Aggregate Size* 1/2" (12.5 mm) % Passing	
	Min.	Max.
#8 2.36 mm)	39.1	39.1
#16 (1.18 mm)	25.6	31.6
#30 (600 m)	19.1	23.1
#50 (300 m)	15.5	15.5

The Superpave aggregate shall meet the requirements of Table 3.

TABLE 3
AGGREGATE TESTING CRITERIA

Test	Criteria	Reference/Comments
Coarse Aggregate Angularity, %	As specified on Plans	NDDOT *Field Sampling and Testing Manual*, the requirement is for one fractured face
Fine Aggregate Anagularity, %	As specified on Plans	AASHTO T 304, the criteria are % air voids in loosely compacted fine aggregate
Clay Content % Sand Equivalent	40 minimum	AASHTO T 176
Flat & Elongated Paraticles, %	10 maximum	ASTM D 4791
Toughness, % Loss	40 maximum	AASHTO T 96
Lightweight Pieces in Aggregate, % Shale	5 maximum	AASHTO T 113, NDDOT Modified
Deleterious Materials % Spall	1.0 maximum	AASHTO T 112, "Clay Lumps and Friable Particles i Aggregate"

410.03 EQUIPMENT.

Equipment shall be as specified in Section 408.03.

410.04 CONSTRUCTION REQUIREMENTS.

GENERAL

Contractor Quality Control. Quality Control (QC) will be the responsibility of the Contractor. The Contractor will perform quality control sampling, testing, and inspection during all phases of the work at a rate sufficient to assure that the work conforms to the contract requirements. The Contractor shall have at least one person on the project, at all times, that is qualified as a bituminous mix controller and one materials tester qualified as a bituminous mix tester. Qualification requirements will be as outlined in the NDDOT Transportation Technician Qualification Program (TTQP). If the Prime Contractor sublets any portion of the contract, including aggregate production, to a Subcontractor, the Subcontractor shall have a person qualified as a bituminous mix controller on the project. If the Subcontractor does not have a qualified person, the Prime Contractor's qualified person shall be on the Project and be in charge of quality control.

Quality Control Plan. Prior to beginning work the Contractor will submit a "Quality Control Plan" to the Engineer. The Plan will contain: 1) the names and phone numbers of the individual(s) responsible for the Contractor's quality control program; 2) a listing of the technician(s) responsible for the quality control testing; 3) an organizational chart indicating lines of authority (including names and phone numbers); 4) a summary of the qualifications of the Quality Control Technicians, and 5) Details of the contractor's quality control plan addressing but not limited to the following items: 1) pit

operations and methods used to control uniformity, reducing segregation, and efficiently utilizing the aggregate resources of the pit; 2) plant operations discussing proposed equipment (number of bins, plant type, etc.) and method of operations; 3) testing frequency and how this meets the intent of the Special Provision; and 4) discussion of how the Contractor's quality control program will respond to the need for corrective action as defined in Section 410.04 Q.

The Department will provide the Contractor with: 1) the names and phone numbers of the individual(s) responsible for project administration; 2) a listing of the technician(s) responsible for the quality assurance testing; and 3) an organizational chart indicating lines of authority (including names and phone numbers).

Quality Control Laboratory. The Contractor will provide a materials tester qualified as a bituminous mix tester to perform all testing including all testing during aggregate production. The Contractor shall also provide testing equipment that meets the requirements for all tests called for by specification.

The Contractor will furnish and maintain a Type C laboratory at the plant as specified in Section 706 of the Standard Specifications. Any other laboratory location must be approved by the Engineer. The laboratory will be furnished with the necessary equipment and supplies for performing the Contractor's QC testing and mix design if specified on the plans, including a Superpave Gyratory Compactor meeting all FHWA and AASHTO T312 requirements. During production of the aggregate, the Contractor may furnish a lab equipped with the necessary equipment to perform the following aggregate tests: bulk and apparent specific gravity, gradation analysis, lightweight pieces of aggregate, plastic index, and fractured faces. The Type C laboratory must be set up and ready to use before the paving operation begins.

Engineer's Laboratory. The Contractor will provide an additional Type C laboratory to be used during actual mix production by the Department's bituminous mix tester. The testing equipment will be provided by the Department. The lab will be set up at the plant prior to production of the bituminous mix and be made available to the Engineer for Quality Assurance testing. The Contractor and the Engineer will share the Gyratory Compactor provided for the Contractors lab.

A. **Pit Operations and Stockpiling of Aggregate.** Stripping of the pit and pit operations shall be conducted according to section 106.02. During production of the aggregate, the aggregate will be tested for gradation, fine aggregate angularity, lightweight pieces of aggregate, flat and elongated pieces, coarse aggregate angularity and clay content. The testing frequency for gradation will be one test per 1,000 tons of material produced for each aggregate stockpile. The testing frequency for lightweight pieces of aggregate, flat and elongated pieces and coarse aggregate angularity will be the average of three random composite samples from the first 5,000 tons of material produced. The testing frequency for the fine aggregate angularity and clay content will be the average of three random samples from the first 5,000 tons of material produced from each stockpile. The fine aggregate angularity and clay content from each stockpile will be combined to determine the final blend results. If all three samples pass, the testing frequency will change to one of three samples tested for each 10,000 tons of material produced. If a sample fails, the remaining two samples will be tested and averaged for acceptance of that lot. The testing frequency will then revert to the average of three tests per 5,000 tons until all three samples pass, then one of three samples will be tested for each 10,000 tons.

1. **NDDOT Developed Mix Design.** The NDDOT will develop the mix design unless the plans specify that the contractor shall develop the mix design.

    a. After 10,000 tons of material is produced, the Contractor will provide the Department with an aggregate sample representing each stockpile and asphalt required for the mix design. The Contractor shall develop a preliminary mix design and submit the results to the department. This mix design is for informational purposes to assure the Contractor has produced specified material. The Department will develop the mix design for the project. The Contractor shall provide all of the information required for the JMF, except Standard PP2, Standard Practice for Short and Long Term Aging of Hot Mix Asphalt. In lieu of the Gyratory Mix Design, the Contractor may provide a Marshall Mix Design meeting the mix requirements for Class 31, in the NDDOT *Field Sampling and Testing Manual* (also see table 5).

    b. When the Department's mix design is approved and testing indicates uniform results for fine aggregate angularity, flat/elongated pieces or course aggregate angularity, and both parties are confident that future production will remain within the specifications, the Engineer, by written notice, may reduce the frequency of the tests.

2. **Contractor Developed Mix Design.** The Plans will specify when the contractor shall develop the mix design.

    a. After production of 5,000 tons and before production of 10,000 tons of aggregate, the Contractor shall develop a preliminary mix design and submit the results to the Department. This preliminary mix design is for informational purposes to assure the Contractor has produced specified material. The Contractor shall provide all of the information required for the JMF, except Standard PP2, Standard Practice for Short and Long Term Aging of Hot Mix Asphalt. In lieu of the Gyratory Mix Design, the Contractor may provide a Marshall Mix Design meeting the mix requirements for Class 31, in the NDDOT Field Sampling and Testing Manual (also see table 5).

    b. After 10,000 ton of material is produced the Contractor shall develop the mix design for the project.

    c. When the Contractor's mix design is approved by the Engineer and testing indicates uniform results for fine aggregate angularity, flat/elongated pieces or course aggregate angularity, and both parties are confident that future production will remain within the specifications, the Engineer, by written notice, may reduce the frequency of the tests.

    The Contractor will sample and test the aggregate according to the Department's *Field Sampling and Testing Manual*.

    The Contractor will provide the Engineer with copies of the test results for each stockpile of aggregate that will be incorporated into the mix by noon of the following day the tests are completed. The test reports will include results for gradation, fine aggregate angularity, lightweight pieces of aggregate, flat and elongated pieces, coarse aggregate angularity, clay content and the bulk and apparent specific gravity.

During the first week of aggregate production, for each class of aggregate, as soon as the Contractor determines the aggregate is representative, and prior to the initial mix design, the Contractor shall obtain a 90-pound sample of each aggregate component. The Contractor shall split the samples under the observation of the Engineer. One-half of each aggregate sample will be submitted to the Engineer for testing. The Contractor and the Engineer will test the samples to determine the bulk (dry) and apparent specific gravity and the percent water absorption by dry weight of aggregate. The testing will be completed according to AASHTO T-84, T-85 and NDDOT Modified test procedures on file in the Materials and Research Laboratory in Bismarck, ND. One test will be performed for each 10,000 ton of each aggregate component produced. A minimum of two tests will be required for each aggregate component. Testing shall commence within 2 working days of sampling. Test results will be reported to each party as soon as they are available.

If the individual specific gravity values determined by the Contractor and NDDOT correlate within 0.040, the average of the Contractor's numbers will be used to calculate the absorption, fines to asphalt ratio, and voids in mineral aggregate (VMA). If the individual specific gravity values determined by the Contractor and NDDOT do not correlate within the allowable tolerance (0.040), or if the Contractor fails to supply an aggregate that meets the mix design criteria then:

a. The mix design will not be approved and mix production will not begin.

b. The Contractor has the option of running the test together with DOT personnel at the District Lab and use those results, or testing differences can be resolved according to the NDDOT's resolution procedures on file in the Materials and Research Laboratory in Bismarck, ND.

If the mix design meets the properties specified and NDDOT and the Contractor mutually agree it is necessary to adjust the aggregate production operation to produce an aggregate that will improve the mix design properties, the Department will negotiate an equitable adjustment with the Contractor to produce an aggregate that meets the desired mix design properties.

B. **Volumetric Mix Design.** The mix design used will be a lab mix design developed by NDDOT or developed by the Contractor, when specified on the plans, and approved by NDDOT. The mix design procedures shall be performed according to the AASHTO Standards outlined in Table 4.

When the NDDOT develops the mix design the Contractor will provide a minimum of 165 pounds (75 kg) of each stockpile and 10 one liter cans of the PG binder, AC specific gravity, and supplier to be used on the project at least 30 days prior to production. A sample tag identifying the project number and pit location shall be attached to each sample. The NDDOT will then have 2 weeks to return a Job Mix Formula (JMF) to the Contractor.

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

The mix design process will consist of two separate mix design procedures. The first will be a Trial Mix Design, the second will be the Final Mix Design. The Trial

Mix Design will determine the aggregate blend to be used in the Final Mix Design.

TABLE 4
AASHTO SUPERPAVE MIX DESIGN STANDARDS

AASHTO Designation	Title
T312	Method for Preparing and Determining the Density of Hot Mix Asphalt Specimens by Means of the SHRP Gyratory Compactor
PP28	Practice for Superpave Volumetric Design for Hot Mix Asphalt
PP2	Practice for Mixture Conditioning of Hot Mix Asphalt
MP2	Specification for Superpave Volumetric Mix Design
T166	Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens

1. **Trial Mix Design/Aggregate Blend Determination.** The Trial Mix Design shall consist of a minimum of three different aggregate blends mixed with a minimum AC content determined by Equation 1. The aggregate shall be blended so that at least one is a coarse type blend, a second is an intermediate type blend and a third is a fine type blend. The 0.45 power chart will be used to determine the blend type. Two plugs shall be compacted for each aggregate blend.

   The number of gyrations used for compaction shall be specified on the Plans. A compaction and volumetric analysis will then be done to determine the estimated blend properties at 4.0% air voids. Each individual blend property will then be compared to the criteria outlined in Table 5. The blend which best fits the criteria will be used for the Final Mix Design. If no blend satisfactorily meets the criteria, one or more new blends will be proportioned and the Trial Mix Design repeated. If the second Trial Mix Design fails to produce a satisfactory aggregate blend then the aggregate production process will be reviewed.

Equation 1

$$\% \text{ Design AC by Weight of Mix} = [(VMA - AV)*(G_b)/(G_{mb})] + \%AC\ abs_{est}$$

Where:
- VMA = Desired mix voids in mineral aggregate
- AV = Desire mix air voids
- G_b = Specific gravity of the asphalt binder
- G_{mb} = Desired bulk spec. gravity of the mix

$\%AC\ abs_{est}$ = Estimated AC Absorption = 0.5* water absorption

TABLE 5
AGGREGATE TESTING CRITERIA

Procedure/Property/Test	Criteria	Reference
Gyratory Compaction Effort, # Gyrations	As specified on Plans	AASHTO PP 28
Voids in Mineral Aggregate, % Minimum	14.0 for 1/2" Nominal Maximum Aggregate[1]	AASHTO MP 2 AASHTO T 166
Voids Filled with Asphalt, %	As specified on Plans	AASHTO MP 2 AASHTO T 166
% G_{mm} @ N_{ini}[2] (Desired)	As specified on Plans	AASHTO MP 2 AASHTO T 166
% G_{mm} @ N_{ini}[2]	98.0 Maximum	AASHTO MP 2 AASHTO T 166
Dust/Effective Asphalt Ratio	0.6 – 1.3 (Top Lift) 0.6 – 1.4 (Bottom Lift)	AASHTO MP 2 AASHTO T 166
Desired Moisture Sensitivity, Min. % Strength Retention[2]	70 @ 7.0 ± 1% Air Voids	AASHTO T 283 AASHTO PP 2
Asphalt Film Thickness[2] (Microns)	7.5 – 13	See Below

[1]Nominal maximum aggregate size is defined as one sieve size larger than the first sieve size to retain more than ten percent of the aggregate.

[2]Desired value, final determination to be made by Materials and Research Engineer.

Determination of Surface Area

Sieve Analysis % Passing											
Sieve	**5/8**	**1/2**	**3/8**	**No. 4**	**No. 8**	**No. 16**	**No. 30**	**No. 50**	**No. 100**	**No. 200**	
Combined Grading	***	***	***	***	***	***	***	***	***	***	
Coefficient				**0.02**	**0.04**	**0.08**	**0.14**	**0.30**	**0.60**	**0.60**	**Total**
Surface Area											

* Film Thickness $FT = \frac{(Pbe)(4885)}{(100)(SA)}$

Where: Pb = asphalt cement, %, mixture basis
Pba = % AC absorbed by weight of aggregate
Ps = aggregate, % mixture basis
Pbe = effective asphalt content, %, mixture basis
FT = film thickness (Microns)
SA = surface area (ft^2/lb)

** The Dust/Effective asphalt ratio shall be determined by dividing the percentage of material passing the #200 sieve by the percentage of effective asphalt added to the mix. The percentage of asphalt used will be as determined in the Mix Design at 4% air voids.

The effective asphalt will be determined as follows: (The formula is as defined in Manual Series No. 2 published by the Asphalt Institute.)

$$Pbe = Pb - \frac{(Pba)(Ps)}{100}$$

*** The gradation used for calculating film thickness and dust/effective A.C. ratio will be the combined gradation results of the actual material used to run the mix design. Perform calculations to the nearest hundredth and round to the nearest tenth.

2. **Final Mix Design/Job Mix Formula Determination.** After the Trial Mix Design is done, the Final Mix Design is conducted. The aggregate blend used shall be the blend determined to best fit Superpave criteria from the Trial Mix Design. Five AC contents will be used in the Final Mix Design. The AC contents used shall be:

   a. The optimum AC content determined by the Trial Mix Design.

   b. 1/2% below the optimum AC content determined by the Trial Mix Design.

   c. 1/2% below the optimum AC content determined by the Trial Mix Design.

   d. 1.0% above the optimum AC content determined by the Trial Mix Design.

   e. 1.0% above the optimum AC content determined by the Trial Mix Design.

   A minimum of two specimens shall be compacted for each AC content. The same criteria for compaction and volumetric evaluation referenced for the Trial Mix Design are used.

   Once the mix is evaluated, graphs representing Air Voids, VMA and VFA versus % AC binder are plotted. The design AC content is then selected for 4.0% air voids. The mix characteristics at the selected design AC content are then compared to the criteria for Fine Aggregate Angularity, Flat and Elongated Pieces, Clay Content, VMA, VFA, % G_{mm} @ N_{ini}, % G_{mm} @ N_{max}, and Dust/Asphalt Ratio outlined in Tables 3 and 5. If the results meet the mix design criteria this mix then becomes the JMF.

   If the results from the Final Mix Design do not meet the mix design criteria then one of the two following options will be selected:

   a. The Final Mix Design will be redone.

   b. Start over with the Trial Mix Design.

3. **Moisture Sensitivity Test.** Once a JMF is determined a moisture sensitivity test will be conducted on the mix according to AASHTO T 283, “Resistance of Compacted Bituminous Mixture to Moisture Induced Damage”. The Marshall specimens shall be compacted to 7.0% ± 1.0% air voids. The tensile strength ratio shall be a minimum of 70%.

4. **Aggregate/Asphalt Supplied Other Than That Used in the Mix Design.** If aggregate or asphalt is utilized from sources other than those initially submitted, the aggregate is processed using a different crusher, or if a different type or grade of asphalt is used, the Contractor shall notify the Engineer in writing 12 working days prior to incorporating the material into the work. If the Engineer determines that a new mix design is required, the Contractor shall provide a sample of the material to the Engineer and allow the NDDOT 10 working days to prepare a new mix design. If the Contractor fails to provide a timely sample, the Contractor shall cease operations and allow the NDDOT 10 working days to prepare a new mix design.

NOTE: Sections C through N are as specified in the respective sections of 408.04, except the mix and compaction temperatures shall be according to the PG binder manufacturers' recommendation.

O. **Independent Assurance.** The Contractor's quality control technician will test the aggregate and bituminous mix as specified and provide split samples to the Department for independent assurance testing. The Department will test the aggregate and bituminous mix at random times throughout the project at the frequencies defined in the Department's *Field Sampling and Testing Manual*. These tests will assure equipment is operating properly and the sampling and testing is performed accurately. Independent Assurance tests for coarse aggregate angularity, fine aggregate angularity, flat and elongated pieces and clay content shall be done during aggregate production at the frequency outlined in Appendix G of the Department's *Field Sampling and Testing Manual*. Test results will correlate within the acceptable tolerance as specified in Table 6.

TABLE 6
ACCEPTABLE TOLERANCES FOR COMPARISON OF CORRELATION TEST RESULTS

5/8" – #4 sieve	± 5%
#30 sieve	± 3%
#200 sieve	± 1.5%
Fractured Faces	± 5%
Air Voids	± 1.0%
Maximum Specific Gravity (Sp. Gr.)	± 0.020
Lightweight pieces of aggregate	± 1%
Bulk Specific Gravity (dry), each aggr. fraction*	± 0.040
Apparent Specific Gravity, each aggr. fraction*	± 0.040
Fine Aggregate Angularity	± 2.5%
Flat & Elongated Pieces	± 2.5%
Clay Content	± 5.0%

*These items are not final mixture acceptance items.

P. **Quality Control Testing.** During production of the bituminous mix, the Contractor will be required to perform random sampling and testing on the aggregate and bituminous mix as the mix is being produced and placed on the roadway. Copies of all test results will be furnished to the Engineer by noon the following day.

The Contractor will sample and test the bituminous mix as outlined in the Department's *Field Sampling and Testing Manua*l.

The Contractor will sample the aggregate from the cold feed and test the aggregate according to the Department's *Field Sampling and Testing Manua*l. The tests will be performed at random times determined by the Engineer and at the frequency specified in Table 7.

TABLE 7
QUALITY CONTROL TESTING FREQUENCIES

Test	**Frequency**
Gradation (use all sieves for Cl. specified)	1/1500 tons
Lightweight pieces of aggregate[1]	3/10,000 tons
Fractured Faces[1]	3/10,000 tons
Maximum Sp. Gr. of Bit. Mix (Rice Method)	1/1500 tons
Bulk Sp. Gr. of Bit. Mix (Plugs) & Air Voids	1/1500 tons
% Asphalt Cement	1/1500 tons[2]
Fine Aggregate Angularity	3/10,000 tons
Flat & Elongated Pieces[1]	3/10,000 tons
Clay Content	3/10,000 tons
% Density of Bit. Mix (Cores)[3]	

[1] The content of the lightweight pieces of aggregate, flat & elongated pieces and fractured faces of the aggregate will be determined by the average of test results from three random samples taken from the cold feed belt for each lot of 10,000 tons or fraction thereof. If all samples pass, only one of the three samples taken will be tested until a sample fails; then the remaining two samples will be tested and averaged for the acceptance of that lot. The testing of three samples per lot will continue until all three samples pass, then one of the three samples will be tested from each lot.

[2] The Contractor will make random checks of the asphalt content each time a gradation test is taken under the observation of the Engineer. The random checks will be based on readings from the totalizers for the aggregate and the bitumen as outlined in the Department's Asphalt Content Determination Report.

[3] The number of tests per lot will be as defined in Section 410.05 C. Compaction.

The Contractor will split and identify all samples. The split samples will be retained by the Contractor for testing by the Engineer. The samples to be tested by the Contractor and given to the Engineer will be large enough to be split again, such that four samples are available for testing. The split samples of aggregate will be stored in a dry, protected location until picked up by the Engineer. The mix samples taken to determine the maximum specific gravity will be split after the sample has been allowed to cool prior to being placed in the flasks.

When quality control samples indicate uniform results on Clay Content or Lightweight Pieces of Aggregate; and both parties are confident that future production will remain within the specifications, the Engineer, by written notice, may reduce the frequency of the tests.

1. **Documentation.** The Contractor will maintain complete records of all process quality control tests and inspections. All test results and calculations will be recorded and documented on data sheets approved by the Department. Copies of the records will be furnished to the Engineer.

   The Contractor will maintain standardized control charts at the field laboratory. Test results obtained by the Contractor will be recorded on the control charts immediately upon completion of the test. The following parameters will be recorded on the control charts:

- Gradation of the control sieves*
- Asphalt Content
- Maximum Specific Gravity
- Bulk Specific Gravity
- Percent Air Voids of field Gyratory plugs
- Daily average Air Voids percentage of the cores
- Average Daily Density
- Fines / Asphalt Ratio (informational only)
- Asphalt Film Thickness (microns) (informational only)

* The control sieves are the 1/2“, #4, #30, and #200 sieves.

The control charts will display the single-test control limits for each test parameter, the individual test results, the moving average control limits, and the moving average of the last four tests. The moving average results and control limits, and the single tests and control limits will be color coded for easy distinction.

The control charts will be displayed at the field laboratory and will be accessible at all times for review by the Engineer.

2. **Control Limits.** The Contractor will maintain the air voids within the allowable working ranges by adjusting the gradation or asphalt content within the allowable working ranges. The target values for the control sieves and the bitumen will be the target values set for the JMF. The field test results may vary from the JMF target values as shown in Table 8.

TABLE 8
ALLOWABLE WORKING RANGES

Parameter	**Single Test Control Limit**	**Moving Aerage Control Limit[1]**
% Lightweight pieces of aggr.	Not more than the maximum specified	
% Fractured Faces	Not less than the minimum specified	
Fine Aggregate Angularity	Not less than the maximum specified	
Flat and Elongated Pieces	Not more than the maximum specified	
Clay Content	Not more than the maximum specified	
1/2” & #4 Sieve	±6	±5
#30 sieve	±5	±4
#200 Sieve[2]	±2.0	±1.5
Asphalt Content	±0.30	±0.24
Air Voids (plugs)	2% to 6%	2.5% to 5%

[1]‘Average of last four tests

[2]Not to exceed the maximum specified.

Q. **Corrective Action.** When a single-test control limit has been exceeded, the Contractor will immediately re-sample and retest. If the re-sample exceeds the control limits, corrective action will be instituted by the Contractor immediately. After the corrective action, the Contractor will immediately re-sample and retest. The corrective action will be documented.

Immediate shutdown will result when two consecutive tests exceed the single–test control limits for percent Lightweight pieces of aggregate, Fine Aggregate Angularity, Coarse Aggregate Angularity, or clay content. Operations will resume when the Engineer is satisfied that corrective action has been taken.

When the moving average values trend toward the moving-average control limits, the Contractor will take corrective action and increase the sampling and testing rate. The corrective action will be documented.

When the moving average of the control sieves or the bitumen exceeds the moving-average control limits, the Contractor may continue production if the air voids are within the control limits and the material passing the number 200 sieve does not exceed the maximum specified. The Contractor will take the necessary corrective action to produce mix based on the JMF or the Contractor may request that new target values be set if the test results indicate that adjustments to the target values are necessary. The Contractor may only make the changes requested with the approval of the Engineer.

When the moving average of the air voids exceeds the moving–average control limit, the Contractor will immediately cease operations unless the Engineer is satisfied that the Contractor is taking corrective action. Quality control testing will resume as soon as the plant has started and operations are equalized.

It will be the responsibility of the Contractor to shut down operations when the control limits are exceeded as specified. Failure to cease operations shall subject all material produced after exceeding the control limits to be considered unacceptable.

R. **Verification Testing.** The Engineer will conduct verification tests on independent samples. Cold feed belt, bitumen samples and coring will be sampled by the Contractor under the observation of the Engineer. The Engineer will test at an increased rate during the first lot of production to determine the accuracy of the quality control testing. Frequencies for verification testing are located in Appendix G of the Department's Sampling and Testing Manual. Test results performed by the Engineer will be available to the Contractor.

The Engineer will observe the Contractor make the random checks for Asphalt Content as specified in Section 410.05.

Samples may be taken and tested by the Department any time the material appears defective or where the Engineer determines that a change in the process or production has occurred.

S. **Hot Mix Asphalt Sampling.** An additional 22 pounds (10 kg) of mix will be taken from behind the paver to accommodate the Superpave Gyratory Compactor (SGC) specimens.

410.05 ACCEPTANCE.

The aggregate gradation pay factor in Section 410.05 A.1 and the bitumen uniformity requirements in Section 410.05 B.2 will not apply when the total plan quantity of hot bituminous pavement is 4,000 tons or less. When the total plan quantity of hot bitumi-

nous pavement is 4,000 tons or less the material will be accepted according to Section 105.07.

A. **Aggregate.**

1. **Gradation.** Aggregate will be sampled and tested in lot sizes equal to the number of tons placed each production day. The aggregate gradation specified will be the basis of acceptance.

   The Contractor shall obtain all aggregate samples at random times determined by the Engineer. The samples shall be taken from the cold feed belt according to AASHTO T-2, Section 4.3.1 or 4.3.2. The sample shall be split into two representative samples, numbered and bagged by the Contractor under the observation of the Engineer. The untested half of the sample will be retained by the Engineer for 24 hours after the test results are make known by the Contractor. Either party may request that the second half of the sample be tested within this 24 hour time frame. The test results from this retest shall replace the test values of the initial test.

   One aggregate sample will be taken for each 1,500 ton of mix produced. Payment for the mix represented by the samples will be based on the uniformity of the test results.

   If any two consecutive tests vary from the JMF gradation target value set for each sieve by more than the tolerances listed below, the pay factor for the full days production will be the lowest pay factor determined from the following formula:

$$\text{Pay Factor} = \frac{100 - \text{Deviation from the Target Range*}}{100}$$

   *Target Range = target value + or – the acceptable tolerance value

   Acceptance of the aggregate will be based on the target values for the control sieves and the allowable working range for the single test control limit as shown in Section 410.04 P Table 8.

   If the average daily air voids of the gyratory specimens are not between 2$ and 5% and the material fails to meet the specifications for 2 consecutive lots, the Contractor shall not incorporate any additional material into the work until the Engineer is satisfied that the Contractor is taking the necessary corrective action to meet the Specifications.

2. **Additional Aggregate Tests.** Aggregate samples to determine shale content, clay content, fractured faces, and L. A. Abrasion loss will be taken by the Contractor, under the observation of the Engineer, before the addition of bitumen to the mix.

   The shale content and clay content of the aggregate will be determined by the average of test results from 3 random samples taken from the cold feed belt from each lot of 10,000 tons or fraction thereof. The samples will be tested and the material will be accepted if the average of the 3 samples meets the specified requirements. If each of the samples is within the specified limits,

only one of the 3 samples will be tested from each subsequent lot. If at any time the sample tested does not meet the specified requirements, the remaining 2 samples will be tested. The average of these 3 samples will then be used to determine acceptance of the material. The testing of 3 samples per lot will continue until all 3 samples are within the specified limits, then only one of the 3 samples will be tested from each subsequent lot. If the average exceeds the specified maximum for shale content, the unit price for the bituminous mixture will be adjusted according to Section 410.07 B. If the average fails to meet the specified requirements for plasticity, the material will be rejected, unless the Construction Engineer elects to accept it under Section 105.07.

The L. A. Abrasion loss percentage of aggregate will be determined on the basis of one composite aggregate sample taken and tested during the beginning of the aggregate stockpiling. If this percentage exceeds the maximum allowable loss, the material will not be accepted.

The percentage of fractured faces for coarse aggregates will be determined by the average of test results from 3 random samples taken from the cold feed belt for each lot of 10,000 tons of bituminous mixture produced. The samples will be tested and the material will be accepted if the average of the three samples meets the specified requirements. If each of the samples is within the specified limits, only one of the three samples will be tested from each subsequent lot. If at any time the sample tested does not meet the specified requirements, the remaining two samples will be tested. The average of these three samples will then be used to determine acceptance of the material. The testing of three samples per lot will continue until all three samples are within the specified limits, then only one of the three samples will be tested from each subsequent lot. If the average fails to meet the specified requirements, the material will be rejected unless the Construction Engineer elects to accept it under Section 105.07.

B. **Bitumen Content.** The required bitumen content, or target percentage, will be designated by the Engineer.

The quantity of bitumen used and paid for from each lot will be determined by the use of daily oil cutoffs following the procedures outlined on the Mix Bitumen Cutoff Report. A lot shall be defined as the amount of bitumen used each production day.

The pay factor for the hot bituminous pavement, adjusted for bitumen content, will be the lowest pay factor determined by both of the following methods:

1. **Average.** If the daily cutoff, as determined on the Mix Bitumen Cutoff Report, deviates from the target percentage set by the Engineer by more than 0.24 percentage points the pay factor will be determined from the following table:

BITUMEN CONTENT

Pay Factor	Deviation from Target in Percentage Points
1.00	.00–.24
.98	.25–.29
.95	.30–.34
.92	.35–.39
*	.40 & Over

*The Construction Engineer will determine the pay factor according to Section 105.07.

2. **Uniformity.** The Engineer will check the asphalt content each time an aggregate sample is taken. The checks will be based on readings from the totalizers for the aggregate and the bitumen as outlined in the Asphalt Content 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 pay factor for the hot bituminous material will be adjusted according to the following formula:

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

*Deviation from the average daily asphalt content.

C. **Compaction.**

1. **Testing.** The compaction of the mixture will be accepted in lot sizes equal to the number of tons placed each production day. The density of the pavement will be determined from cores obtained by the Contractor, as specified in Section 410.05 C.2.

   Each sublot will be one paver width wide, excluding the shoulders, 2,000 feet long, and of the depth specified for the pavement course. If the partial sublot remaining at the end of a production day is 1,000 feet in length or longer, it will be considered a separate sublot. If it is less than 1,000 feet long, it will be included in the last complete sublot. If the total day's production is less than 2,000 feet long (one paver width wide), that production will be considered a lot.

   The mean density of the mainline pavement placed each production day will be the average of the densities of all of that day's sublots. In addition to testing randomly selected locations, the Engineer reserves the right to direct the testing of any areas which appear defective. Defective areas will be rejected unless the Engineer elects to accept it under Section 105.07.

   The Contractor, under the observation of the Engineer, shall:

   a. Obtain mix samples from behind the paver at random times specified by the Engineer. One sample shall be taken each time an aggregate sample is taken; and

   b. Compact two gyratory specimens with each sample taken to determine the field gyratoryl density. The number of blows applied to the gyratory

specimens shall be 50, unless otherwise specified, and the temperature of the mix shall be 270°F plus or minus 55°F.; and

c. Determine the Maximum Theoretical Density of each sample taken.

The methods used to obtain the samples, compact the gyratory specimens and determine the

Maximum Theoretical Density shall be as outlined in the Department's Field Sampling and Testing Manual.

2. **Contractor Coring.** The Contractor shall take two cores in each sublot at a random location determined by the Engineer and under the observation of the Engineer. After coring and sawing, the cores shall be handed over to the Engineer. The cores shall be taken adjacent to each other and the average of the two cores shall be used for determining the density of the sublot.

The Contractor shall take two additional full–depth cores per mile, with one location in each lane, for the District Materials Coordinator to use as an independent assurance test. The District Materials Coordinator will determine the locations of these cores. The cores shall be marked and delivered to the District Materials Laboratory. The cores shall not be sawed by the Contractor.

The coring machine shall cut a cylindrical sample in the compacted asphalt lift without disturbing the density of the sample. The core samples shall be 4 to 6 inches in diameter. The masonry saw shall cut the core sample so only the compacted layer to be tested is removed; and the core is in a condition suitable for testing.

Coring of each day's paving shall be completed no later than the next working day following the placement of the lift. Cores shall be taken through the full depth of the in-place asphalt pavement. The surface of the outside of the cores shall be smooth with no distortion of the cylindrical shape or displacement of the aggregate particles. A masonry saw shall be used to remove the compacted layer from the full-depth core without damaging the newly placed asphalt material.

The Contractor shall fill all holes remaining in the surface of the roadway with bituminous material and compact the material as directed by the Engineer. Each core shall be numbered or lettered to identify the location from which the core was taken. The marking system shall meet the approval of the Engineer.

The Contractor may elect to take a check sample, at the Contractor's expense, whenever the average density of a set of cores is 89% or less than the Theoretical Maximum Density. A check sample shall be a set of cores taken within 2 feet of the location of the failing set of cores. The average density of the check sample cores will be the result used to determine the Unit Price of the hot bituminous pavement.

Retests and additional tests will not be taken or paid for unless approved by, or directed by, the Engineer.

The Contractor shall control traffic according to the traffic control plan to ensure the safety of the coring crew and the traveling public. The Engineer may

alter these requirements depending on the location of the coring operation in respect to the existing traffic control zone, and in situations where traffic is being controlled by a pilot car and/or flaggers. Coring operations shall not take place adjacent to the paver to avoid blocking traffic.

3. **Compaction Payment Schedule.**

a. Acceptance of mainline pavement placed on any production day will be based on the average density of the pavement compared to the daily average maximum theoretical density (MTD) determined for each lot of pavement placed. The average density of the field cores shall be at least 91% of the daily average MTD. Each individual sublot shall have an average density of at least 89% of the daily average MTD. If the average density of the field cores is less than 91% of the daily average MTD or any sublot is less than 89% of the daily average MTD the Unit Price of the hot bituminous pavement will be adjusted according to the following tables:

PAVEMENT DENSITY
ADJUSTMENT OF UNIT BID PRICE PER LOT

Pay Factor A	**Average Pavement Density**
1.00	91% or greater
.99	90.0% – 90.9%
.975	89.0% – 89.9%
.95	88.0% – 88.9%
.925	87.0% – 87.9%
*	Less than 87.0%

Pay Factor B	**Lowest Density of any Sublot**
1.00	89% or greater
.99	88.0% – 88.9%
.98	87.0% – 87.9%
.97	86.0% – 86.9%
.96	85.0% – 85.9%
*	Less than 85.0%

*The Engineer will determine whether the material may remain in place. The Pay Factor for the material allowed to remain in place shall be .70 for Pay Factor A and .80 for Pay Factor B.

The density of the field cores will be determined according to the Department's Field Sampling and Testing Manual. The Total Pay Factor will be the product of the pay factor for the average pavement density and the lowest sublot.

TOTAL PAY FACTOR = (PAY FACTOR A) × (PAY FACTOR B)

D. **Verification Testing / Quality Control Testing Tolerances.**

A table for comparison of Verification Testing and Quality Control Testing is located in Appendix G of the Department's Sampling and Testing Manual.

410.06 METHOD OF MEASUREMENT.

The estimated quantities provided may be adjusted by the Engineer in the field. Any increase or decrease in the quantities used shall not be a basis for renegotiation in the price bid for these items.

A. **Hot Bituminous Pavement.** Hot Bituminous Pavement will be measured by the Ton or Square Yard according to Section 109. Batch weights will not be permitted as a method of measurement unless the plant is equipped with an automatic batching and weighing system with an automatic printer system which prints the weights of each batch and issues a weigh ticket for each load. The tonnage will be the weight used in the accepted pavement and no deduction will be made for the weight of bitumen used in the mixture.

B. **Bitumen.** Bitumen will be measured according to Section 109 and the quantity of bitumen will be the number of Tons or Gallons used in the accepted work.

C. **Cored Sample.** Each individual cored sample that is removed in the required condition will be measured as a unit. The work vehicle, coring machine, masonry saw, and shadow vehicle will not be measured for payment, but will be included in the measurement of the cored sample.

D. **Testing.** All cost incurred for the Quality Control Testing, and contractor developed mix design when specified on the plans, will be measured and paid at the unit price per ton for testing.

410.07 BASIS OF PAYMENT.

Payment will be made at the Contract Unit Price for the following:

Pay Item	**Pay Unit**
Hot Bituminous Pavement Superpave	Ton
Asphalt Cement	Ton or Gallon
Cored Sample	Each
Testing	Ton

This payment will be full compensation for all labor, equipment, and materials necessary to complete the work.

When price adjustments are required for failing material or patching, payment will be made as follows:

A. Determination of the payment adjustment of a lot of bituminous mixture will be make by successively multiplying the Contract Unit Price per Ton of the bid item by the applicable pay factors as determined in Sections 410.05 A, 410.05 B, and 410.05 C.

B. When the average of the test results specified in Section 410.05 A.2 shows a larger shale content than the maximum allowable specified, the following deduction from the Bid Price for the bituminous mixture item will be made:

One percent reduction in unit price for each 0.2% above the maximum allowable percentage. If the percentage of shale exceeds the allowable limits by 2% or more,

the material will be rejected unless the Engineer elects to accept it under Section 105.07.

This reduction will apply to lots of 10,000 tons, and will be applied independently of Section 410.05 A.1.

C. Material for patching or leveling of an existing bituminous surface constructed under a previous contract shall be obtained from the tonnage provided in the basis of estimate and will be paid according to Section 408.07 C.

SECTION 411
MILLING PAVEMENT SURFACE

411.01 DESCRIPTION.

This work consists of improving the profile, cross slope, and surface texture of an existing pavement surface.

411.02 EQUIPMENT.

The Milling Machine shall meet Section 152.05.

411.03 CONSTRUCTION REQUIREMENTS.

The existing pavement surface shall be cleaned of deleterious material before the milling operation.

The milling shall be started at the centerline of the pavement and proceed on a longitudinal line parallel to the centerline. Succeeding passes shall progress toward the outer edge of the pavement unless a different sequence of operations is permitted by the Engineer. Milling shall progress in a manner that a single lane is not more than one day's run in advance of the adjacent lane. The Contractor may be required to alter the milling operation to best suit construction conditions. When the milling is stopped, the milled depth shall be gradually tapered to the original pavement surface.

The completed milled surface shall be free from transverse and longitudinal irregularities exceeding 1/4 inch when measured with a 10-foot straightedge.

The Contractor shall dispose of the milled material as indicated in the Contract.

When the material is stockpiled, the stockpile site shall be shown on the Plans or if not shown, the Contractor shall select the site. The stockpile site shall be prepared according to Section 405.02 A.

The Contractor shall clean the milled surface by brooming before opening to traffic.