2301
Concrete Pavement

2301.1 DESCRIPTION

This work shall consist of constructing Portland cement concrete pavement on a prepared base.

2301.2 MATERIALS

A Concrete 2461

A1 Incentives/Disincentives

When the Contract includes concrete aggregate and water-cementitious incentive/disincentive provisions, they shall apply only to materials provided for or produced by the Contractor's primary concrete paving plant. The primary paving plant may be a batch plant or a ready mix plant. The use of any one kind or class of material from more than one source is prohibited without permission from the Engineer. Permission, if granted, will set forth the conditions under which the change of source is allowed.

The incentive/disincentive provisions shall not apply to materials provided for or produced by a secondary concrete plant providing mixture for minor work such as fill-ins or other work not provided by the Contractor's primary concrete plant.

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A3 Class R as the Coarse Aggregate

For 100 percent Class R coarse aggregate concrete mixes, the mix designations shall be as given below for the method of placement to be used.

Manual Placement..... Mix No. 3A40R
Standard Machine Placement..... Mix No. 3A30R
Vibratory Machine Placement ..... Mix No. 3A20R

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A5 Concrete Paving Aggregate

A5aRequired Preliminary Aggregate Testing

As soon as coarse and fine aggregate is available for testing, the Contractor shall contact Mn/DOT or designated representative to coordinate preliminary sampling of aggregate for concrete paving. Mn/DOT will sample and test the aggregate to update specific gravity and absorption data and perform other tests as determined by the Engineer.

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A5c Coarse Aggregate Quality Control/Quality Assurance (QC/QA) Incentive/Disincentive

Acceptance of the coarse aggregate for paving concrete shall be by statistical methods. This provision is in addition to all other requirements of 2301, 2461, and 3137. Sufficient aggregate must be produced 4 weeks prior to the commencement of paving operations to provide sufficient time for verification testing.

The QC/QA program for CLASS B and C Aggregates will comply with the following procedure:

(1) The aggregate producer will produce a 1000 metric ton (**ton**) stockpile of each fraction of aggregate that is to go into the work.

Then, production shall cease for 4 business days to check aggregate quality. The Engineer and the aggregate producer, in the presence of one another, shall take 3 split samples of each stockpile and each run the appropriate test, depending on the aggregate class, to examine aggregate quality. The aggregate producer can use this correlation to aid in the quality control of the aggregates. If the Mn/DOT test results indicate that the aggregate is acceptable, production can resume. If the test results are unacceptable, the stockpile will be rejected and the procedure will start again after the aggregate producer has corrected the operation.

(2) After acceptability is verified, the aggregate producer will continue to take quality control samples for testing at the rate of 1 sample per fraction per ½ day of production during the entire period of aggregate production. The appropriate test for the aggregate class will be run as soon as possible after sampling. For each fraction, the aggregate producer will plot the test results on a chart indicating the specification limits for the appropriate test. The aggregate producer shall make changes in the operation if the material approaches the specification limit.

(3) The Engineer will take acceptance samples at a location as close as possible to incorporation into the work (the belt leading to the weigh hopper is the suggested location). The acceptance sampling rate shall be as follows:

Plan m^3 (**cubic yards**) of concrete	Samples per fraction (n)
1,000 – 10,000	5
10,000 – 40,000	10
40,000+	15

The acceptance samples will be randomly chosen. A lot representing the plan m^3 (**cubic yards**) of concrete will be divided by the number of samples to form sublots. The number of m^3 (**cubic yards**) in a sublot is multiplied by a random number (Attachment A) between 0.00 and 0.99 to obtain the position in the sublot for the sample. The samples will be split and half left for the aggregate producer. The Engineer's laboratory will test the samples and report the individual results. The Engineer will calculate a Quality Index (QI) for each fraction as follows:

$$QI = X+k(s) \text{ where: } X=\text{mean}=\sum X_i/n$$

X_i = individual quality test results

K	**No. of Tests**
1.23	5
1.26	10
1.27	15

s = standard deviation

$$s = \sqrt{\Sigma(X_i - X)^2/(n-1)}$$

For Class B aggregate the special quality requirement is absorption and:

QI for Fraction %	Structural Concrete m^3 (**cubic yards**) Payment Change Per Fraction
≤1.00	+ $1.30 (**$1.00**)
1.01 - 1.45	+ $0.65 (**$0.50**)
1.46 - 1.76	0
1.77 - 1.85	- $1.30 (**$1.00**)
≥ 1.86	Recommendation of State Concrete Engineer

For Class C aggregate the special quality requirement is % carbonate, and:

QI for Fraction %	Structural Concrete m^3 (**cubic yards**) Payment Change Per Fraction
≤ 15.0	+ $1.30 (**$1.00**)
15.1 - 24.0	+ $0.65 (**$0.50**)
24.1 - 31.0	0
31.1 - 35.0	- $1.30 (**$1.00**)
≥ 35.1	Recommendation of State Concrete Engineer

Class A aggregates (including quartzite and gneiss), if meeting all other Mn/DOT requirements, qualify for $1.30 per m^3 (**$1.00 per cubic yard**) per fraction incentive.

Class R aggregates are not considered in this incentive/disincentive program.

If the concrete mixture contains 3 or more fractions of coarse aggregate (such as 19 mm+, 19 mm-, 9.5 mm- (**¾ inch+, ¾ inch-, 3/8 inch-**)). only the 2 containing the highest percentage by weight are eligible for incentive. Two or more sub-fractions may be combined (such as 19 mm- (**¾ inch-**) and 9.5 mm- (**3/8 inch-**) sub-fractions combined to produce the 19 mm- (**¾ inch-**) fraction) to form either the coarse or fine fraction of the coarse aggregate. The sub-fractions shall be blended by weight. Therefore, the maximum incentive for aggregate quality is $2.60 per m^3 (**$2.00 per cubic yard**) of structural concrete.

A5d Optional Incentive for Well-Graded Aggregate

An optional incentive of $2.60 per m^3 (**$2.00 per cubic yard**) of concrete is available to the Contractor provided a concrete mixture is designed and produced with a combined aggregate gradation that meets the following requirements:

Sieve Sizes	% Retained
50 mm (**2 inch**)	0%
37.5 mm (**1 ½ inch**)	≤ 8%
25 mm (**1 inch**)	8% to 18%
19 mm (**3/4 inch**)	8% to 18%
12.5 mm (**1/2 inch**)	8% to 18%
9.5 mm (**3/8 inch**)	8% to 18%
4.75 mm (**# 4**)	8% to 18%
2.36 mm (**# 8**)	8% to 18%
1.18 mm (**# 16**)	8% to 18%
600 µm (**# 30**)	8% to 18%
300 µm (**# 50**)	≤ 18%
150 µm (**# 100**)	≤ 8%
75 µm (**# 200**)	≤ 1.6%

If the previous gradation is not met an optional incentive of $0.65/$m^3$ (**$0.50 per cubic yard**) of concrete is available to the Contractor provided a concrete mixture is designed and produced with a combined aggregate gradation that meets the following requirements:

Sieve Sizes	% Retained
50 mm (**2 inch**)	0%
37.5 mm (**1 ½ inch**)	≤ 7%
25 mm (**1 inch**)	7% to 18%
19 mm (**3/4 inch**)	7% to 18%
12.5 mm (**1/2 inch**)	7% to 18%
9.5 mm (**3/8 inch**)	7% to 18%
4.75 mm (**# 4**)	7% to 18%
2.36 mm (**# 8**)	7% to 18%
1.18 mm (**# 16**)	7% to 18%
600 µm (**# 30**)	7% to 18%
300 µm (**# 50**)	≤ 18%
150 µm (**# 100**)	≤ 7%
75 µm (**# 200**)	≤ 1.6%

Compliance is determined based on the Contractor's composite aggregate gradation test results as verified by Agency testing.

The Agency's statistical analysis of samples for well-graded aggregate

control incentive will be based on a lot basis representing one days paving. The incentive payment shall be calculated on a lot basis. The lot represents the cumulative average of the sublot values on each sieve.

A6 Cementitious Materials – General

The minimum cementitious material requirements shall be (315 kg/m^3 (**530 pounds per cubic yard**). Of the cementitious fraction, the minimum portland cement content shall be 237 kg/m^3 (**400 pounds per cubic yard**) whether using fly ash or ground granulated blast furnace slag as a portland cement replacement (See below for Special Requirements for Quartzite and Gneiss) . Any additional cementitious material necessary to meet any requirement described herein shall be the responsibility of the Contractor with no additional compensation from the Agency. Total cementitious shall not exceed 356 kg/m^3 (**600 pounds per cubic yard**) except for high-early mixes.

Mn/DOT 2461.3D is modified to allow up to 30 percent replacement with fly ash. Portland cement may be replaced with up to 35 percent ground granulated blast furnace slag (GGBFS), however, ternary mixes (Portland cement, GGBFS, fly ash or other cementitious materials) are not allowed.

Specification 3101 is hereby modified such that the total alkalis in the portland cement ($Na_2O + 0.658\ K_2O$) shall not exceed 0.60 percent. The total alkalis in the cementitious material shall not exceed 3.0 kg/m^3 (**5.0 pounds per cubic yard**).

A6a Special Cementitious Requirements for Quartzite and Gneiss

If the Contractor selects to use coarse aggregate from sources identified by Mn/DOT as quartzite or gneiss and the aggregate does not comply with the 0.04 percent expansion limits of ASTM C-1293, the other cementitious material shall be:

(1) 30% of an approved fly ash meeting the following requirements:

Mn/DOT 3115 is modified such that fly ash used as cementitious material in the concrete mixture shall have a minimum $Si0_2 + Fe_2O_3 + Al_2O_3$ of 66.0% on a dry weight basis. In addition, it shall have a minimum $Si0_2$ content of 38.0%.

-or-

(2) 35% of an approved ground granulated blast furnace slag.

A7 Concrete Mix Design

The Contractor shall review the Special Provisions of the Contract to determine which of the following specifications apply. If nothing is specified then 2301.A7a shall apply. If the concrete paving is < 385 m^3 (**500 cubic yards**) then 2461.4D7a shall apply.

A7a Small Concrete Paving Projects > 385 m^3 (**500 cubic yards**) and ≤ 3825 m^3 (**5000 cubic yards**)

Unless modified in the Special Provisions of the Contract, the following

shall apply:

A7a(1) Mix Design

Grade A paving concrete shall be designed and placed at a water cementitious ratio not greater than 0.40. The Mn/DOT Concrete Engineering Unit shall provide the mix design. In lieu of a mix design provided by the Mn/DOT Concrete Engineering Unit, the Contractor has the option to supply the mix design.

A7a(2) Optional Contractor Mix Design

The Contractor shall design the concrete paving mixture based on a volume of 1.000 m^3 (**cubic yard**) according to industry standard practice.

The concrete pavement placement may commence 15 days after preliminary approval of the Contractor's concrete pavement mix design by the Concrete Engineer. Final approval of the mixture is based on satisfactory field placement.

A7a(3) Coarse Aggregate Gradation

All coarse aggregate for concrete pavement that does not contain 100% recycled concrete shall meet the following gradation:

Sieve	Percent Passing
50 mm (**2 inch**)	100
37.5 mm (**1 1/2 inch**)	95-100
19 mm (**3/4 inch**)	35-70
9.5 mm (**3/8 inch**)	10-30
4.75 mm (**#4**)	0-7

A7a(4) Admixtures (Other than Mineral Admixtures)

An approved Type A water reducing admixture shall be used. (Approved list on file at the Departments' Concrete Engineering Unit Website) The use of any admixtures other than air entraining agents and Type A water reducers require the approval of the Concrete Engineer.

A7b Large Concrete Paving Projects > 3825 m^3 (**5000 cubic yards**)

Unless modified in the Special Provisions of the Contract, the following shall apply:

A7b(1) General

The concrete pavement placement may commence 15 days after preliminary approval of the Contractor's concrete pavement mix design and job mix formula (JMF) by the Concrete Engineer. Final approval of the mixture is based on satisfactory field placement.

A7b(2) Contractor Concrete Mix Design

The Contractor shall design the concrete paving mixture based on a volume of 1.000 m^3 (**cubic yard**) according to industry standard practice.

Grade A paving concrete shall be designed and placed at a water cementitious ratio not greater than 0.40.

High early mixes may have up to 100 % portland cement. High-early mixes are not eligible for incentive payments for water/cementitious ratio.

For the minor work such as fill-ins or other work not provided by the Contractor's primary concrete plant, the Contractor may choose to use a 3A41HE mix designed by Mn/DOT in lieu of the Contractor mix design requirement.

A7b(3) Job Mix Formula

A Formula (JMF) containing proportions of materials and individual gradations of each material plus a composite gradation. All admixtures shall also be included. The JMF shall be based on the combination of coarse and fine aggregate for the following sieves:

50 mm (**2 inch**), 37.5 mm (**1-1/2 inch**), 25 mm (**1 inch**), 19 mm (**3/4 inch**), 12.5 mm (**1/2 inch**), 9.5 mm (**3/8 inch**), 4.75 mm (**# 4**), 2.36 mm (**# 8**), 1.18 mm (**# 16**), 600 µm (**# 30**), 300 µm (**# 50**), 150 µm (**# 100**) and 75 µm (**# 200**). During the testing process, additional fill-in sieves may need to be added to prevent overloading. Table 3137-1 and Table 3137-2 and the gradation requirements of Mn/DOT 3126 are hereby deleted. The percent passing the 50 mm (**2 inch**) sieve shall be 100 percent; the percent passing the 75 µm (**# 200**) sieve shall not exceed 1.6 percent.*

*(Note: See Mn/DOT 3137.2D1i for additional requirements for coarse aggregate cleanliness.)

The JMF submittal shall include working ranges based on the composite gradation of the above sieves

The working range limits of the composite gradation are based on a moving average of 4-tests (N=4). The working ranges are:

Sieve Size	Working Range
4.75 mm (**# 4**) sieve or greater	+/- 5 %
2.36 mm (**# 8**) to 600 µm (**# 30**) sieve	+/- 4 %
300 µm (**# 50**) sieve	+/- 3 %
150 µm (**# 100**) sieve	+/- 2 %

A new concrete mix design and JMF shall be submitted if the moving average falls outside of the JMF working range or any proportions of the mix design are adjusted.

A7b(4) Admixtures (Other than Mineral Admixtures)

An approved Type A water reducing admixture may be used at the discretion of the Contractor. (Approved list on file at the Departments' Concrete Engineering Unit Website). The use of any admixtures other than air entraining agents and Type A water reducers require the approval of the Concrete Engineer.

A7b(5) Water/Cementitious Ratio

The water/cementitious ratio shall conform to the requirements of Table WC-1. Statistical analysis may indicate a percentage of the production is

above or below the specified requirement. Concrete represented by water/cementitious ratios above the limits listed in the Table may be removed and replaced by the Contractor. If the Contractor elects not to remove the material and the level of payment is not defined in the table, the material will be evaluated by the Concrete Engineer as to the adequacy for the use intended. All concrete evaluated as unsatisfactory by the Concrete Engineer for the intended use shall be removed and replaced by the Contractor at no expense to the Agency.

The Agency's determination of the water/cementitious ratio will be based on the following procedures:

(1) Water Content

(a). For a concrete paving batch plant, the water added to the mix (including temper water) shall be recorded by an electronic meter approved by the Engineer that records and prints the amount of total water including temper water as part of each batch ticket.

For a ready mix plant, the water added to the mix (including temper water added and other trim water added prior to placement) shall be recorded on the computerized Certificate of Compliance. The water content for calculating w/c shall be based on the average water computed from 10 batch tickets/Certificates of Compliance surrounding the randomly selected batch ticket sample (4 previous tickets, ticket representing the random sample, 5 following tickets).

(b). For a batch plant, the water content in the mix determined in "a" shall be verified with samples taken from the plastic concrete at the plant site.

For a ready-mix plant, the water content shall be verified in the field or at the plant site at the discretion of the Engineer. Samples transported to the plant site for testing must be packaged in a manner that will prevent moisture loss.

The water content in the plastic concrete mixture is determined by test procedure AASHTO Designation: TP23-93 "Standard Test Method for Water Content of Freshly Mixed Concrete Using Microwave Oven Drying". The test must commence within 45 minutes after the water has contacted the cementitious material. **The Contractor shall supply the microwave oven and the ancillary equipment necessary to perform the above test.**

The water content in the concrete mix used for the determination of the water-cementitious ratio consists of the free water (water in excess to absorbed water) carried by the aggregate plus the water added to the mixer. The moisture contents of the aggregates (all fractions) are determined by the Agency according to *the Agency Quality Assurance Testing Rate*. Close coordination is required to assure that the aggregate samples taken for moisture determination represent the same material as the plastic concrete mix sample taken for microwave water content determination.

(2) Cementitious Content

The cementitious content is the target value (mix design weights) printed

on the batch ticket/Certificate of Compliance as verified by cement cutoffs. Adjustments for mix going to commercial or other agency work may be necessary.

The Agency's statistical analysis of acceptance samples for water/cementitious ratio will be based on a lot basis representing one days paving. Paving includes integrant curb and gutter and curb and gutter placed adjacent to the concrete mainline with the same mixture as used in the paving. A new mix design shall dictate a new lot. On the last day of paving or on the last day of using a specific mix design, the concrete involved shall constitute separate lot/sublot unless the above applies regarding less than 3 sublots.

The Agency's acceptance samples shall be randomly chosen. The location of the sample shall be determined using a random number chart and multiplying the random number by the sublot size. (Example: Random number (0.65) X 750 m^3 (**1000 cubic yards**) results in taking a sample from the load representing the 488th cubic meter (**650th cubic yard**)).

The samples will be tested by Agency personnel and the individual results recorded.

The Engineer will calculate a Quality Index (QI) for each lot as follows:

QI = X where: X = mean = $\sum X/n$ (Rounded to the nearest hundredth)

X = Individual water/cementitious tests (Rounded to the nearest hundredth)

n = Number of tests

Concrete mix not meeting the 0.40 water/cementitious requirement shall not knowingly be placed in the work. Should any non-conforming material be inadvertently placed in the work, it will be accepted for payment according to Table WC-1.

Table WC-1	
QI Value	Payment incentive/disincentive per m^3 (cubic yard)
0.35 or less	+$5.20 (**$4.00**)
0.36	+$3.90 (**$3.00**)
0.37	+$2.60 (**$2.00**)
0.38	+$1.62 (**$1.25**)
0.39	+$0.65 (**$0.50**)
0.40	0.00
0.41	-$0.65 (**$0.50**)
0.42	-$1.62 (**$1.25**)
0.43	-$2.60 (**$2.00**)
0.44	-$3.90 (**$3.00**)
0.45+	Determined by the Concrete Engineer

Price adjustments based on the Table WC-1 shall apply to Item 2301.511 (Structural Concrete) only.

A7b(6) Contractor Testing

As part of the Contract, the Contractor shall provide qualified personnel and sufficient equipment meeting the requirements listed in the Mn/DOT Concrete Manual to conduct quality control testing.

The Contractor shall calibrate and correlate the testing equipment with prescribed procedures and conduct tests in conformance with specified testing procedures as listed in the Mn/DOT Concrete and Laboratory Manuals. Gradations for both coarse and fine aggregate shall be mechanically sieved.

The Contractor shall maintain and keep current control charts. The charts shall be an easily readable size and be displayed on the testing facility wall or stored in a 3-ring binder. Test data from such characteristics as moisture content of aggregates and total water in mix, w/c ratio, composite gradation, air content and flexural strength shall be plotted on control charts. The charts shall contain the following characteristics: date, time, lot and sublot, applicable specifications and other data necessary to facilitate control of the process.. Batch weight adjustments shall be noted on the control charts under a remarks column. The Engineer will approve all charting procedures.

Reports, records, and diaries developed during the progress of construction activities shall be filed at the direction of the Engineer and will become the property of the Agency. Reports shall include:

(1) Copies of all test results and control charts at the completion of concrete paving operations

(2) Copies of all failing test results sent by facsimile on a daily basis to the Project Engineer and the District Materials Engineer. Failure to provide daily test results shall be grounds for suspension of plant operations.

A8 Testing Rates

Testing rates shall comply with the Schedule of Materials Control unless modified in the Special Provisions of the Contract.

B	**Reinforcement Bars**	**3301**
C	**Dowel Bars**	**3302**
D	**Steel Fabric**	**3303**
E	**Blank**	
F	**Concrete Joint Sealers,**	
F1	Hot-Poured, Crumb Rubber Type	3719
F2	Hot-poured, Low Modulus Type	3720
F3	Preformed Type	3721
F4	Hot-poured, Elastic Type	3723
F5	Hot-poured, Elastic Type	3725
F6	Silicone Type	3722
G	**Preformed Joint Filler**	**3702**
H	**Curing Materials**	
H1	Waterproof Curing Paper	3752
H2	Plastic Curing Blankets	3756

H3 Membrane Curing Compound 3754
H4 Extreme Service Membrane Curing Compound 3755
I Blank
J Form Coating Material 3902

2301.3 CONSTRUCTION REQUIREMENTS

Unless otherwise stated in the Special Provisions, the "Slip Form" method of construction is the standard construction method. In this case references to the use of fixed side forms or to the use of equipment designed to ride on fixed forms shall not apply.

A General

A1 Operation and Supervision

Construction operations shall not be started until the Engineer has determined that all equipment, tools, inspection facilities, preliminary testing, and accessories necessary for the phases of work being undertaken at the time are on the work site and meet the Specification requirements as to design, capacity, and mechanical condition.

The Contractor shall submit to the Engineer an organizational chart listing names and phone numbers of individuals and alternates responsible for mix design, process control administration, and inspection. The organizational chart shall be posted in the Contractor's on site facility.

The Contractor's quality control organization or private testing firm shall have Mn/DOT Certified Technicians. All testing and plant operations shall be overseen by a Quality Control Supervisor who is a Concrete Plant Level II Technician certified by Mn/DOT. The Quality Control Supervisor must be on site at all times or have a cellular phone in their possession and must be able to be at the plant site in a reasonable time frame when called. Individuals performing mix design calculations or mix design adjustments must be certified as a Concrete Plant Level II Technician. Individuals performing process control testing must be certified as a Concrete Plant Level I Technician.

The Agency and Contractor shall complete and sign a Paving Contact Report to verify all requirements are met.

The Contractor shall have in the Project organization a separate foreman, sub-foreman, or designated worker in charge of each phase of the work requiring direct supervision, who is authorized to receive instructions and orders in the absence of the general foreman or superintendent. Major phases of the work requiring this direct supervision shall be as follows:

(a) Aggregate producing plant, if operated as a part of the Contract.
(b) Concrete batching and mixing plant.
(c) Subgrade preparation and fine grading.
(d) Form setting (if required)
(e) Concrete placing.
(f) Finishing and curing.
(g) Joint sealing and cleanup.

The Contractor should also have available a manufacturer's manual that explains the operation and adjustments of the major pieces of power operated equipment to be used.

A2 Combination Plant Lab – Office Requirements

The following special requirements apply for concrete paving projects which meet the requirements of 2301.2A7b.

A separate combination Plant Lab-Office shall be furnished for use during the concrete paving operation. This combination Plant Lab – Office shall be shared equally by the Concrete Paving Contractor QC technicians and the Agency QA technicians. This combination Plant Lab – Office supplied by the Concrete Paving Contractor shall be considered incidental and shall meet the requirements of Mn/DOT 1604.

The Contractor's testing facility shall be located at the plant site and be approved by the Engineer prior to the commencement of concrete production. Any other location must be approved by both the Engineer and the Concrete Engineer. The Contractor shall provide suitable space and specified testing equipment for their quality control personnel to perform the required tests.

The combination Plant Lab – Office will be constructed and equipped to all provisions of Mn/DOT 2031.3A except as modified below:

a. Minimum total floor area, based on exterior dimensions, will not be less than 21 m^2 (**224 square feet**).
b. Minimum Plant Lab floor area, based on exterior dimensions, will not be less than 13.5 m^2 (**144 square feet**).
c. Minimum Plant Office floor area, based on exterior dimensions, will not be less than 7.5 m^2 (**80 square feet**).
d. Plant Lab and Plant Office areas will be separated by a wall to effectively isolate the Plant Lab from the Plant Office.

In addition to the requirements set forth above, each combination Plant Lab – Office will be equipped to meet all the provisions of Mn/DOT 2031.3B1 (Field Office Furnishings) and Mn/DOT 2031.3B2 (Field Laboratory Furnishings) except as modified below:

(a) Plant Office Furnishings

1. Two (2) desks with minimum total exterior dimensions of ¾ m by 1.50 meters (**30 x 60 inches**). One each for the Agency and Contractor.
2. Sufficient desk chairs to utilize all desks and provide seating for at least two additional persons.
3. Two (2) file cabinets with two or more file drawers. One each for the Agency and Contractor.
4. To facilitate communication between the Contractor and the Engineer regarding quality control,, the Contractor shall provide a working telephone, working copy machine and working fax machine. The Contractor shall provide local and long distance telephone service in the Plant office only for the duration of concrete paving operations. The Contractor shall pay for the telephone installation, the basic monthly phone service charges and the

eventual removal of the telephone. Payment for local telephone service will be considered incidental for which no direct payment will be made. The Contractor shall bill Mn/DOT for long distance phone charges by sending an invoice and a copy of the long distance charges, provided said charges were not incurred by the Contractor, his employees, his subcontractors, or suppliers.

(b) Plant Laboratory Furnishings

1. One sturdily built workbench or countertop with minimum dimensions of 0.75 x 3.65 m (**30 x 144 inches**) to be shared equally between the contractor and agency.
2. Shelf space above workbench or countertop or at other convenient locations, totaling a minimum of 2.5 m (**8 linear feet**) length by (0.20 m (**8 inches**) minimum width).
3. Electronic balances/scales for all materials testing.

In addition to the requirements set forth above, the combination Plant Lab – Office will meet requirements of Mn/DOT 2031.3C. Type D service will be provided with the exception that toilet and lavatory facilities are not required.

Concrete paving operations will not be permitted to begin until the combination Plant Lab – Plant Office meets all requirements herein.

A3 Equipment Restrictions

Equipment, other than sawing equipment, shall not operate on the new pavement slab until the joints have been sealed. Equipment operated on a slab shall be designed, equipped, and operated so as not to cause damage. Should any damage result, the operations shall be suspended until corrective action has been taken. In no case shall the equipment wheels or tracks be operated within 100 mm (**4 inches**) of the slab edge.

The Contractor shall not operate paving or other heavy equipment on a new pavement slab until the concrete has attained an age of 7 days or until it has a minimum flexural strength meeting the minimum requirements of 2301.3A7 and then only when authorized by the Engineer. The concrete test specimens shall be cast, cured, and tested as prescribed in the Mn/DOT Concrete Manual. When such paving operations are authorized, the following conditions shall be complied with:

(a) Before moving on and off the pavement, a ramp of compacted earth or other suitable material of sufficient strength and elevation shall be constructed to prevent undue stress in the pavement slab.

(b) The paving equipment shall operate on protective mats consisting of wood strips, belting, or other suitable material to prevent damage to the pavement surface and joints. The pavement surface shall be swept free of debris prior to placing the protective mats.

A4 Integrant Curb

Integrant curb is a curb that is constructed monolithically with the pavement.

A5 Permanent Terminal Headers

This work shall consist of constructing concrete pavement terminal headers at the locations shown in the Plans and as directed by the Engineer in accordance with Mn/DOT 2301, the details shown on Standard Plate No. 1150.

A6 High Early Strength Sections

Where so indicated in the Plans or directed by the Engineer, a section of pavement shall be constructed of high early strength concrete at important road crossings, intersections, driveway entrances, or other locations where early use of the pavement may be required to accommodate traffic.

Because of the accelerated rate of hardening of high early strength concrete, the Contractor shall take such extra precautions as necessary to ensure satisfactory finishing of these sections.

High-early concrete is defined as a concrete mixture having a cementitious content greater than 356 kg/m^3 (**600 pounds per cubic yard**). High Early mixes shall be designed to provide a maximum water/cementitious ratio of 0.40 and a minimum flexural strength of 3450 kPa (**500 psi**) or a minimum compressive strength of 20.7 Mpa (**3000 psi**) in 48 hours. High early mixes may have up to 100 % portland cement. High-early mixes are not eligible for incentive payments for water/cementitious ratio.

For the minor work such as fill-ins or other work not provided by the Contractor's primary concrete plant, the Contractor may choose to use a 3A41HE mix designed by Mn/DOT in lieu of the Contractor mix design requirement.

A7 Closed Period for New Pavement

New pavement shall not be opened to use by any traffic until the joints have been sealed.

Newly constructed pavement may be opened to use by light vehicles (axle loads of 2700 kg (**6000 pounds**) or less) 72 hours after the concrete has been placed.

New pavement shall be closed to use by construction and general public traffic for 7 days or according to the values listed in the Table 2301-A whichever is the shorter. When the opening of new pavement to traffic is to be determined by flexural strength, the test specimens shall be cast and tested as prescribed in 2461.4A5. The test specimens shall be cured in the same manner and under the same conditions as the pavement represented.

Table 2301-A
Minimum Strength Requirements for Opening Pavements to Construction and General Public Traffic

Slab Thickness mm (**in.**)	Flexural Strength Mpa (**psi**)
150 (**6.0**)	3.4 (**500**)
165 (**6.5**)	3.4 (**500**)
175 (**7.0**)	3.4 (**500**)
190 (**7.5**)	3.3 (**480**)
200 (**8.0**)	3.2 (**460**)
215 (**8.5**)	3.0 (**440**)
225 (**9.0**)	2.7 (**390**)
240 (**9.5**)	2.4 (**350**)
255 (**10.0**)	2.4 (**350**)
≥265 (**≥10.5**)	2.4 (**350**)

B Subgrade Preparations

The aggregate base construction and subgrade preparations, as provided for in 2211 and 2112 respectively, shall be completed in sufficient time to permit all tests and measurements to be completed prior to the fine grading operation. The subgrade shall then be fine graded to the required shape and grade to ensure construction of pavement meeting the specified thickness and cross section. Fine grading shall be accomplished with a template planer or other suitable machine capable of producing the necessary finish. Fine grading operations shall be completed at least 3 hours in advance of concrete placement, except on crossovers and other such small areas as the Engineer exempts.

If the slipform method of construction is used, the base course from out to out of the paver treads shall be accurately fine graded to the required elevation by an approved fine grading machine mounted on crawler treads. Base construction shall be completed and the required subgrade density obtained to a width at least 1 m (**3 feet**) beyond the outside edges of the pavement treads before the fine grading is performed. The aggregate base shall have sufficient stability and firmness to support the fine grading equipment and slipform paver without any serious distortion of the alignment or grade line.

Following the fine grading operations, the subgrade shall be recompacted as necessary to produce a firm smooth subgrade. Water shall be added as necessary during the recompacting operations, and the subgrade shall be maintained in a moist condition until placement of the concrete. The subgrade shall be rechecked with a suitable device prior to placing the concrete, if paving equipment or hauling equipment has been operating thereon. The Engineer may recheck the density of the base after completion

of fine grading operations. Any disturbed material shall be recompacted.

The Contractor shall shape the shoulders in such a manner and to such an extent that surface water will drain away from the pavement and off the shoulders. The Contractor shall maintain the shoulders in that condition.

C Form Placement and Removal

C1 Form Sections

Regardless of type or design, forms shall have a height at least equal to the edge thickness of the pavement and shall have a strength and rigidity such that, when they are set in place and braced, they will withstand the mass (**weight**) and action of passing equipment without springing, settlement, or lateral displacement. Individual form sections shall be connected by methods that will secure the effect of a continuous form.

Form sections shall be not less than 3 m (**10 feet**) long except that wood forms may be 2.4 m (**8 feet**) or more in length. Approved flexible or curved forms of proper radius shall be used on curves having a radius of 45 m (**150 feet**) or less, except that, on curves having a radius greater than 30 m (**100 feet**), straight forms not over 3 m (**10 feet**) in length may be used when power operated strike-off and finishing equipment is used. The finished face of all curbing shall be constructed and finished to a line closely conforming to the Plan curvature and location. Straight forms longer than 3 m (**10 feet**) shall not be used on any curved line unless specifically authorized by the Engineer.

The top surfaces of all forms shall be smooth and free of localized indentations and deformities, and shall show no deviations greater than 3 mm (**1/8 inch**) from a straight edge having a length equal to the form section. The faces of straight forms shall show no deviations greater than 13 mm (**½ inch**) from a 3 m (**10 foot**) straight edge.

Integrant curb forms shall conform to the applicable requirements for paving forms and shall be equipped with clamps or other satisfactory means to ensure their support and alignment.

C2 Form Setting

The Contractor shall set the forms to the proper alignment and grade for a distance equal to at least 3 hours of paving time ahead of the paver, except when less than that quantity of paving remains to be done.

The foundation upon which the forms will be set shall be compacted in accordance with 2301.3B. The forms shall have a firm and uniform bearing over their whole base area; shall be tightly joined and securely staked; and shall be clean and free of accumulations of hardened concrete. The contact faces of the forms shall be coated with a chemical release agent conforming to 3902 prior to placing the concrete against them.

In the event of rain, the forms shall be removed and reset as necessary to permit drainage and comply with the above requirements.

C3 Keyway Forms

Keyway forms that are attached to the side forms may be cut off not more than 75 mm (**3 inches**) from each end of the form section length. All keyway forms for fixed form paving shall be manufactured to the Plan dimensions.

C4 Removal of Forms

Side forms for pavement and back forms on integrant curb shall not be removed earlier than 12 hours after the concrete has been placed, except that the Engineer may authorize earlier removal based on the procedure to be used.

Forms shall be removed in a manner that exerts no apparent shock or strain on the pavement or curb and under satisfactory conditions of visibility (such as natural daylight), as determined by the Engineer.

D Batch Hauling

Concrete shall be hauled in trucks that are mortar tight and capable of complete discharge of the concrete. The trucks shall be equipped with vibrators to aid in such discharge. Dump type trucks shall not dump concrete directly on the grade unless approved by the Engineer, and such approval will only be granted when the dimensions of the work make other methods impractical.

Any truck operations on the base will be subject to 2301.3B.

E Placing Metal Reinforcement

All metal reinforcement shall be clean when used. The forms shall be of the type, style, and dimensions shown in the Plans, unless otherwise approved.

Metal reinforcement shall be placed at the locations shown in the Plans and in accordance with the following:

E1 Blank

E2 Bar Reinforcement

All bar reinforcement except dowel bars will be classified as Reinforcement Bars. Reinforcement bars include, but are not limited to, joint ties and construction headers.

All reinforcement bars shall be epoxy coated in accordance with 3301.

Bar reinforcement of greater section area than that specified in the Plans may be used at the Contractor's option, but the spacing between the individual members shall not exceed the spacing shown in the Plans for the type of reinforcement and bar size specified.

Unless otherwise shown in the Plans, splices in reinforcement bars shall not be less than 40 diameters and the overlapped ends shall be securely tied with wire. All reinforcement bars shall be placed on chairs or by appropriate equipment for depressing the bars to the specified location.

The tie bar steel required for L1T joints shall be placed by an approved mechanical device attached to the spreader or paver. Such device shall space and depress the tie bar steel to the desired depth and location.

E3 Dowel Bars

The Contractor shall:

(a) Furnish dowel bar assemblies that are fabricated in single units for the appropriate lanes. Use not more than two assembled sections in any one joint for ramps, loops, and tapered sections.

(b) Secure the dowel bar assemblies so movement does not occur while concrete is being placed. See Standard Plate 1103.

(c) Remove assembly ties and other similar materials that are parallel to the dowel bars so that there is at least a clearance of 150 mm (**6 inches**) from the anticipated joint centerline to ensure proper joint movement.

(d) Blank

(e) Coat the dowel bars:

(1) With a thin uniform coating of an approved form coating material meeting 3902,

(2) For a minimum of one-half of the dowel length plus 50 mm (**2 inches**), and

(3) Within 1 hour before covering with concrete.

(f) Mark the location of all doweled contraction joints in order to ensure accurate placement of the weakened plane of the joint during subsequent operations.

F Batching and Mixing

The Contractor shall batch and mix the concrete, and perform all related operations in accordance with 2461 and the following additional requirements.

F1 General

The Contractor shall check measuring equipment before paving operations are started and at any other time when there is evidence of improper operation. The batching and mixing of concrete shall not start until proper operations are ensured. The Engineer may suspend paving when improper operations are observed.

Admixtures shall be agitated in order to ensure homogeneous concentrations. When mixing operations are first started on the Project, the mixer timing device shall be set to produce an operating timed cycle of 75 seconds for all single drum mixers and 55 seconds for all dual drum mixers. This cycle shall remain in effect until the mechanical operating constants of the mixer can be accurately determined. The Engineer will then make such modifications in the cycle as may be necessary to conform to 2461.4C.

Batching and mixing operations shall be suspended whenever satisfactory finishing and curing of the pavement cannot be carried on properly.

F2 Cement Cutoff and Yield

The Contractor shall make positive cement cutoffs, except when the proportioning is performed in a commercial ready-mix plant and the batch is delivered to the construction site in revolving drum agitator type trucks. The positive cement cutoffs shall be made in accordance with the following provisions:

(a) A cement cutoff shall be made when approximately 250 metric tons (**500,000 pounds**) of cement have been used and again prior to the use of 1000 metric tons (**2,000,000 pounds**). Thereafter, a cement cutoff shall be made at least every 1500 metric tons (**3,000,000 pounds**) or once a week, whichever provides the longer time interval between cutoffs.

(b) When bulk cement is delivered directly to the concrete batching plant in

railroad cars or sealed transport trucks, the Contractor shall deliver to the Engineer copies of the freight bills the same day they are received from the transporting company.

(c) Blank

(d) The Contractor shall advise the Engineer of the method and schedule of cement unloading. The unloading of cement shall not begin until the Engineer approves the operation.

Individual cutoffs shall not show an underrun in cement usage exceeding 1.5 percent of the quantity specified, nor shall the final cutoff show an overall underrun exceeding 1.0 percent. If either one or both of these limitations are exceeded, the concrete represented thereby will not be paid for at the Contract unit bid prices. Unless the Engineer determines that the pavement is so deficient in cement content as to constitute unacceptable work, the defective concrete will be paid for at an adjusted unit price having the same ratio to the Contract unit price as the quantity of cement used has to the quantity of cement required. The quantity required will be the specified quantity less the allowable underrun. In case both tolerances are exceeded, the price adjustment will not be applied to both conditions, but only to the one that produces the greatest payment deduction.

F3 Basic Scale Requirements

The Contractor shall inspect, test, and calibrate the scales according to 1901 and the Mn/DOT Concrete Manual, after being set up. The initial spot check for accuracy and sensitivity shall be made before starting production operations. A copy of the inspection certificate shall be furnished to the Engineer.

F4 Cement Batching

The Contractor shall:

(a) Weigh bulk cement within a tolerance of 1 percent.

(b) Submit the cement records to the Engineer.

F4a Interlocking Device

The Contractor shall furnish an interlocking device when the quantity of concrete to be produced and placed is more than 750 m^3 (**1000 cubic yards**).

The cutoff gates for cement batching shall be automatic and shall be controlled by the scale mechanism. The hopper inlet mechanism of the cement batching equipment shall be interlocked with the discharge gate to prevent opening the hopper inlet gate while the discharge gate is open. The hopper discharge mechanism shall be interlocked with the scale mechanism to prevent:

(1) Opening the discharge gate during filling until the full quantity of the cement is in the hopper and the scale is balanced.

(2) Opening the discharge gate if the quantity of cement in the hopper is out of range of the specified tolerance.

(3) Closing the discharge gate until the cement is entirely discharged from the hopper and the scale is back in zero balance.

F4b Cement Scale and Cement Recorder

The Contractor shall equip the cement scale with an automatic cement recorder that will record the mass of cement in each batch.

The automatic cement recorder shall be graphic, digital, or photographic, and shall meet the requirements shown in the Mn/DOT Concrete Manual. It shall register both empty balance and total mass (**weight**) of each batch. The recorder shall be located and housed to protect against dust, moisture, and vibration. The housing shall be capable of being locked and, unless the recorder is photographic, the batch mass (**weight**) shall be observable without unlocking.

The cement scale may be equipped with manual controls for emergency use in the event of trouble with the automatic controls. In the event of trouble with the automatic controls, manual weighing will be permitted for a period not to exceed 5 days, provided the cement recorder is in proper working order.

In the cement batching operation, the Contractor will be permitted to override the automatic controls infrequently for periods not exceeding 15 minutes duration, provided the cement recorder is in proper working order. In the event of trouble with the cement recorder, the cement batching operation will be permitted to continue for a period not to exceed 1 working day, provided the automatic controls are in proper working order and the batching is performed automatically. The Contractor may substitute a photographic recorder if the malfunctioning recorder cannot be repaired within the 1 working day. The Contractor shall immediately cease batching operations if the substitute recorder is not fully operational.

F5 Aggregate Batching

The batching of aggregates shall conform to 2461.4B4.

F6 Other Cementitious Materials Batching

The batching of any other cementitious materials shall conform to 2301.3F4.

G Placing Concrete

All main line pavement constructed by standard or vibratory machine placement methods shall be constructed in a single layer of concrete.

The Contractor shall sprinkle the subgrade as necessary to provide a moisture content in the upper 75 mm (**3 inches**) of the subgrade (at the time of concrete placement) such that there will not be excessive absorption of water from the concrete into the subgrade soil.

The concrete shall be deposited so as to form a continuous mass requiring a minimum of rehandling or redistribution and of sufficient depth to provide the necessary excess for subsequent finishing operations. The concrete shall not be dumped or discharged in any manner that will cause its displacement.

Premixed concrete may be hauled to the placement site in dump trucks, subject to 2301.3D.

The concrete along header joints shall be consolidated by internal vibration prior to final finishing.

Manhole and catch basin frames or rings shall be set to the required elevation during the paving operations.

Water shall not be added to the surface of the concrete to aid in finishing without the approval of the Engineer. The Engineer will only give this approval to replace evaporated surface water directly behind the paver caused by a halt in forward progress from a short-term breakdown in equipment or supply of concrete. The Contractor shall supply sufficient trucks to assure a steady forward progress of the paver. Pavement sections where water is added without the approval of the Engineer shall not be eligible for incentive payment for w/c or ride and are subject to the provisions of Mn/DOT 1503 and 1512.

Should placement of concrete be temporarily suspended, the placement operations shall be resumed in such manner that will not result in a cold joint or honeycombing. If the suspension period exceeds 90 minutes, a standard header joint shall be constructed.

When placing concrete adjacent to inplace concrete pavement joints, protect all ends of transverse joints to the satisfaction of the Engineer to prevent concrete mortar from infiltrating into the existing joints and causing compression spalls.

H Fixed-Form Construction

In all cases the concrete shall be struck-off as soon as practicable after it has been deposited on the subgrade, after which it shall be screeded twice. Manual placement methods will be permitted only when the dimensions of the work make the use of standard power-operated equipment impractical or as a temporary measure in cases when the power-operated equipment breaks down. Self-propelled, power-operated finishing equipment will not be required on pavements less than 3 m (**10 feet**) in width nor when there is less than 2500 m^2 (**3000 square yards**) of pavement to be placed.

H1 Vibratory Machine Placement

The following requirements shall apply to fixed-form pavement construction using concrete designed for vibratory machine placement:

H1aStrike-off and Screeding

The Contractor shall use sufficient strike-off and screeding equipment to keep pace with the placement of concrete.

The Contractor shall provide at least one mechanical spreader equipped with a reciprocating screed at least 300 mm (**12 inches**) wide and with full width vibratory equipment, plus one standard finishing machine. A mechanical spreader shall be a unit designed for the sole purpose of spreading and consolidating the concrete between the side forms to a uniform cross section.

There shall be an initial strike-off, followed by a first and second screeding operation. The machine used for these operations shall carry a proper excess of concrete or mortar ahead of and along the full length of the screeds and vibrators, and the operations shall be conducted in a manner that will not displace or damage joint assemblies. Excess water and laitance brought to the surface by these operations shall be wasted over the forms.

Power-operated finishing machines shall be equipped with either a single reciprocating screed not less than 500 mm (**12 inches**) wide or with two reciprocating screeds, one of which shall be at least 300 mm (**20 inches**) wide.

The second screeding movement shall be carried forward for a distance of not less than 30 m (**100 feet**) at a time, except that, if the rate of paving progress is less than 30 m (**100 feet**) per hour, the distance shall be equal to 1 hour's paving progress. If the forward progress is such that the second screeding operation cannot be performed properly, the rate of concrete placement shall be reduced or additional screeding equipment shall be used.

H1b Portable Vibrator Operation

Concrete adjacent to side forms and fixed structures shall be consolidated by means of portable vibrators or by "fins" attached to full width vibratory equipment. The portable vibrator shall operate at a speed of not less than 60 Hz (**3600 VPM**). While in operation, the vibrator head shall not be permitted to come in contact with the subgrade. In the event of failure of the vibrator, and if no replacement unit is available, the concrete in these areas may be consolidated by means of hand spading for the remainder of the day.

H1cFull-Width Vibrator Operation

Full-width vibrators shall operate between 60 (**3600 VPM**) and 100 Hz (**6000 VPM**) in the concrete and between 70 (**4150 VPM**) and 115 Hz (**6900 VPM**) when checked in air. The vibrators may be either of the surface or internal vibration type. The vibrator impulses shall be delivered directly to the concrete and the intensity of vibration shall be sufficient to consolidate the concrete mass thoroughly and uniformly throughout its entire depth and width.

The rate of progress of the vibratory equipment and the duration of the application shall be so regulated that the concrete is fully but not excessively vibrated. Excessive vibration, as indicated by segregation or undesirable water gain in the upper zone of the segregation or undesirable water gain in the upper zone of the pavement, will not be permitted. The operation of vibrators shall be suspended when the forward progress is interrupted.

If the vibratory equipment temporarily fails or if its use is discontinued, the work may continue by using the standard machine placement method of consolidation, provided the concrete mixture is redesigned for that method. Any increase in concrete or cement costs resulting from such change shall be borne by the Contractor.

H1d Pan Finishing

Except as otherwise provided hereinafter, all concrete that has been consolidated and screeded with power-operated machines shall be further smoothed by a pan-type float finisher. The pan-type finishing unit shall include two reciprocating screeds and the pan float. The second screed board and the pan float shall be suspended from the frame of the unit near the mid-span of the wheel base. The pan float shall not be supported by or permitted to ride on the side forms. The screeds on the pan-type finisher will be considered as performing the second screeding operation. The pan-type finishing machine shall be operated in the forward direction only, without

stops or reversals, except in case of emergency.

The use of power-operated pan floats will not be permitted on areas of pavement where the crown or elevation must be adjusted or warped to meet that of an intersecting pavement, or where the number, size, or location of manholes or other appurtenances will interfere with or delay the operation of the float. In such cases, the surface shall be finished with metal-shod long-handled floats.

H2 Standard Machine Placement

The concrete shall be designed for standard machine placement. The operations and equipment shall be the same as those specified for the vibratory machine method of placement, except as modified hereinafter.

There shall be at least one mechanical spreader and one standard finishing machine. On single lane construction and on widening lanes, the floating may be performed either with manual or power operated floats. Mechanical spreaders will not be required on pavements constructed 6 m (**19 feet**) or less in width.

Full width vibratory equipment will not be required. No consolidation of the concrete will be required, other than that obtained through operation of the finishing machine, and except as provided for concrete consolidation by means of the portable vibrator according to 2301.3H.

H3 Manual Placement

The concrete shall be designed for manual placement, and the manually operated screeds shall be operated over each section of the pavement so constructed as many times as necessary to produce a surface conforming to the Plan crown and gradient of the pavement.

Manually operated screeds shall be steel-shod and be equipped with vibrators, pull rods, and handles. They shall be shaped as required by the nature of the work.

I Blank

J Slipform Construction

The concrete shall be designed for vibratory machine placement when the slipform method of construction is to be used, and the concrete shall be placed with an approved slipform paver designed to spread, consolidate, screed, and float finish the freshly placed concrete in such manner that a minimum of hand finishing will be necessary to provide a dense and homogenous pavement in conformance with the Contract. The slipform paver shall have (as one of its components) a non-oscillating extrusion plate with an adjustable angle of entry.

Consolidation shall be accomplished with vibrating tubes or arms working in the concrete or with a vibrating screed or pan operating on the surface of the concrete. Vibrators shall operate at the frequencies listed for full-width vibrators in 2301.3H. Internal vibrators shall be spaced at 600 mm (**24 inches**) intervals maximum for slipform machine speeds of less than 5 m (**16 feet**) per minute and at 450 mm (**18 inch**) maximum intervals for speeds of 5 m (**16 feet**) per minute or greater. The outer vibrators shall operate at a distance of 150 to 225 mm (**6 -9 inches**) from the edge of

concrete.

An electronic monitoring device displaying the operating frequency of each individual internal vibrator shall be required for concrete pavement that is placed by the slipform method. The monitoring device shall have a readout display near the operator's controls visible to the paver operator and the Contracting Authority. It shall operate continuously while paving, and shall display all the vibrator frequencies with manual and automatic sequencing among all individual vibrators. The monitoring system shall also record at a minimum, the following: clock time, station location, paver track speed and operating frequency of individual vibrators. Recordings shall be made (at a minimum) after each 7.62 m (**25 feet**) of paving or after each 5 minutes of time. A record of the data (CD) shall be provided to the Contracting Authority upon completion of the concrete paving operation or daily, if requested.

The cost of furnishing, installing, and monitoring vibrators and vibrator monitoring devices shall be considered incidental to the Contract unit price for PCC pavement.

The concrete shall be maintained at a uniform consistency, as will produce no appreciable edge slump or irregular edge alignment. Consistency requirements will be modified as necessary. Edge slump in excess of 5 mm (**1/8 inch**) will not be allowed.

The slipform paving operations for mixing, delivering, spreading, and extruding the concrete shall be coordinated to provide uniform progress of the paver. If, for any reason, it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately.

When specified for automatic grade control, the paver shall be so equipped. These automatic controls shall be capable of maintaining the proper elevation at both sides of the paver by controlling the elevation of one side and controlling the crown, or by controlling the elevation of each side independently. The grade reference shall be achieved by means of an erected string line.

Erected string line control shall consist of a tightly stretched wire or string, offset from and parallel to the pavement edge on one or both sides, and set parallel to the established grade for the pavement surface. The Contractor shall set this control reference and shall support the line at intervals as close as necessary to maintain the established grade and alignment. The control line shall be set sufficiently in advance of paving to avoid delays.

K Joint Construction

Unless otherwise indicated in the Plans, all joints shall be perpendicular to the subgrade. Dowel bars shall be placed parallel to the subgrade and parallel to the centerline of the pavement.

Contraction joints shall be spaced at the intervals shown in the Plans except that, adjacent to header joints, reinforced panels, railroad grade crossings, and the free ends of pavement, the spacing shall be shortened as as necessary to provide panel lengths not less than 3 m (**10 feet**) long.

Initial joint sawing shall be approximately 3 mm (**1/8 inch**) wide and to

the full joint depth. The initial sawing shall be accomplished as soon as the condition of the concrete will permit without raveling and before random cracking occurs. The sequence of initial sawing shall be at the Contractor's option. Widening of the joints to full width shall not be performed until the concrete is at least 24 hours old and shall be delayed longer when the sawing causes raveling of the concrete.

The location of each transverse joint shall be marked in a manner satisfactory to the Engineer, prior to placement of the concrete and, in the case of joints that are to be sawed, the markings shall be transferred to the fresh concrete as soon as the final finishing operations have been completed. Water under nozzle pressure shall be used to remove the sawing residue from each joint and the pavement surface immediately after completing the sawing of that joint.

Preformed joint filler material for expansion joints shall be staked in place in order to maintain its proper position during concrete placement. The filler material shall have a metal shield on the top edge to protect the material and maintain proper alignment. The shield shall be removed after completion of the longitudinal floating over the joint and while the concrete is still plastic.

Transverse joints constructed in the pavement shall be extended through the integrant curb.

When placing concrete adjacent to inplace concrete pavement joints, protect all ends of transverse joints to the satisfaction of the Engineer to prevent concrete mortar from infiltrating into the existing joints and causing compression spalls.

L Surface Finishing

After the concrete has been consolidated, screeded, and floated, the pavement surface shall be given a final finish texture. This final finish shall be obtained by drawing a carpet drag longitudinally along the pavement before the concrete has attained its initial set. The drag shall be mounted on a bridge. The dimensions of the drag shall be the width of the concrete placed by a longitudinal length having sufficient surface contact to produce a texture satisfactory to the Engineer.

The carpeting for the carpet drag shall be an artificial grass type having a molded polyethylene pile face with a blade length of 15 to 25 mm (**5/8 -1 inch**) and a total minimum mass of 2.35 kg/m^2 (**weight of 70 ounces per square yard**). The backing shall be of a strong, durable material not subject to rot, that shall be adequately bonded to the facing to withstand use as specified.

In addition to and immediately following the carpet drag, provide the pavement surface with a transverse metal-tine texture. This operation requires a mechanized device providing a randomized spacing of 16-26 mm (**approximately 5/8 -1 inch**). The required tine width is 2-3 mm (**approximately 1/12 -1/8 inch**) and the required tine depth is 3-8 mm (**approximately 1/8 - 5/16 inch**) with care not to dislodge coarse aggregate particles. Manual methods for achieving similar result may be used on ramps and other locations approved by the Engineer. Other texturing equipment

may be approved for use provided an equivalent texture is obtained.

The above specified metal-tine texturing will not be required on such subsidiary paving areas as cross-overs and parking lanes as the Engineer exempts, or on certain restricted speed limit areas (under 55 km/h (**35 miles per hour**)) as specifically exempted in the Contract or by the Engineer.

M Concrete Curing and Protection

The Contractor shall:

(1) Cure and protect the concrete by the blanket curing method or one of the membrane curing methods.
(2) Cure the entire pavement surface and edges as soon as surface conditions permit after the finishing operations.
(3) Continue curing and protecting the concrete for at least 72 hours.
(4) Place the curing media on the pavement edges within 30 minutes after removal of the forms when side forms are used.
(5) Extend the minimum curing period to 96 hours when fly ash or Portland-pozzolan cement substitutions are used.
(6) Use the extreme service membrane curing method after September 15 north of the 46 degree parallel, after October 1 south of the 46 degree parallel, and before April 15.
(7) Provide sufficient curing blankets as described in 2301.3M1 to readily protect the concrete from rain and cold temperature when the membrane curing method is used.

M1 Blanket Curing Method

The pavement surfaces shall be covered with waterproof paper or plastic sheeting as soon as possible (without marring the pavement) after completion of the finishing operations.

The curing blankets shall be in such a condition and shall be so placed as to provide an airtight and moisture proof covering that will prevent loss of water vapor from the underlying pavement during the curing period. When placed, the adjoining blankets shall overlap at least ½ m (**18 inches**). This lap shall be secured with a windrow of earth to form a closed joint, and each blanket shall have a windrow of earth along the edges of the pavement to hold the blanket in place. Additional mounds of earth shall be placed at random over the blanket to prevent displacement or billowing of the blankets by the wind. After removal of forms, the extra width provided in the blankets or the stringer strips shall be folded down over the sides of the pavement and be secured by a continuous windrow of earth as a seal. Plowing of this windrow into place will not be permitted.

M2 Membrane and Extreme Service Membrane Curing Method

The exposed surfaces of the concrete shall be coated with membrane curing compound immediately after the last texturing operation. The only exception is when the concrete must be protected from adverse weather conditions and the Contractor elects to do this by placing plastic sheeting over the concrete; the curing membrane must then be applied immediately after the sheeting is removed. The compound shall be applied with an approved fully-automatic spraying machine, at the minimum rate of 4 m^2/L (**150 square**

feet per gallon) of surface area.
Hand operated spray equipment may be used for applying the compound on pavement edges and irregular shaped surfaces.

Before being placed in the spray equipment, the compound shall be thoroughly mixed in the shipping containers by the use of compressed air, or by other approved means. All emulsion type cures shall be protected from freezing while in storage on the job site and while in the spray equipment.

The equipment shall be operated in a manner that will direct the membrane compound to the surface from two different lateral directions. When a single set of nozzles is mounted on a bar that extends longitudinally over the pavement, the compound shall be applied in two passes of the nozzles over the surface, one in each direction. When two sets of nozzles are mounted on two transverse lines over the pavement in a staggered manner and the membrane compound from either set of nozzles will uniformly cover the pavement surface, application may be accomplished in one pass of the unit. If used, the spray bar drive system shall operate independently of the wheels or track drive system. The equipment shall also include a storage tank with an agitator, a filter system, check valve nozzles, and a shield to control loss of material by wind action.

Should any spot check indicate a deficiency in material usage appreciably below the specified minimum rate, the surface area in question shall be resprayed or shall be covered with curing blankets. Also, should the membrane film become damaged at any time within the required curing period, the damaged areas shall be repaired immediately by respraying.

N Joint Sealing

The Contractor shall not seal joints until they have been inspected and approved by the Engineer. At the time they are sealed, the concrete shall be surface dry and the joints shall be thoroughly cleaned of all debris, dirt, dust, and other foreign matter, including accumulations of concrete. Just before the joints are sealed, the Contractor shall clean the joints with a jet of compressed air under pressure of not less than 580 kPa (**85 pounds per square inch**). The Contractor shall seal integrant or tied curb joints with the same joint sealer as used to seal the pavement joints.

Table 2301-N defines what type of sealant shall be used in the longitudinal joints based on what sealant type is used in the transverse joints.

Table 2301-N

If the transverse joints is:	Seal the longitudinal joints with:
3721 – Preformed Elastomeric	3723 – Hot Pour
3722 – Silicone	3723 – Hot Pour
3725 – Hot Pour	3725 – Hot Pour

If the type of sealant for transverse joints is not specified elsewhere in the Contract, the Contractor shall select an approved 3722 silicone sealant from the list of approved products available on Mn/DOT'sConcrete Engineering Unit website.

When any fraction of the coarse aggregate in the concrete mixture is Class B aggregate, joint sealing with 3722 silicone is not allowed.

The handling and placing of joint sealer material shall be performed in accordance with the following provisions:

N1 Hot Poured Sealers

Hot poured sealers shall be heated in a double-boiler type kettle or melter having the space between inner and outer shells filled with oil or other heat transfer medium. The heating equipment shall include automatic temperature control, mechanical agitation, and recirculating pump provisions. Since some materials are subject to damage by overheating, reheating, or prolonged heating, proper care and equipment shall be used as recommended by the manufacturer of the sealer material.

Prior to final compressed air cleaning, the joint walls shall be lightly sandblasted.

The ambient temperature of the pavement shall be above 4ºC (**39ºF**) during application of the sealer.

N2 Silicone Sealers

Silicone sealers shall be installed according to manufacturers recommendations.

Joints shall be filled in a neat, workmanlike manner and in conformance with the tolerances shown in the Plans. The use of a backup material or bond-breaker in the bottom of the joint will be required to control the depth of sealant, achieve the desired shape of the sealant, and support the sealant against indentation and sag. The backup and bond-breaker materials shall be compatible with the sealer. Any joints filled above permissible level shall be corrected by removing and replacing the sealer at no expense to the Department.

As the joint filling operations progress, the sealant surface shall be dusted with talc or be covered with single layer paper tissue to prevent small incompressible particles (stone pebbles and chips) from bonding to the exposed tacky surface.

Heating and filling operations shall be coordinated so that no more sealer material is melted than can be used the same day. Once the sealer material has been heated to application temperature it shall be so maintained until it is

placed. The sealer material shall be placed within 4 hours after the initial heating to the application temperature.

N3 Preformed Sealers

The seals shall be furnished in one continuous length for each joint, except that:

(a) In contraction joints, butt splices will be permitted at longitudinal joints, and

(b) In expansion joints, one butt splice per lane width will be permitted, provided the splice is made by factory methods that have been approved by the Materials Engineer.

In its final position in the joint, the upper corners of the preformed seals shall be below the pavement surface as shown in the Plans, and the walls of the seal shall not fold over at the top of the joint.

Stretching of the sealer material in the installation process shall not exceed 5 percent of the joint length.

Wherever an expansion joint abuts aggregate or bituminous surfaced shoulders, the ends of the expansion joint shall be sealed in the same manner as the top portion of the joint. A wedge-shaped section shall be removed from the bottom part of the seal where it makes a right angle turn from the top to the side of the joint. The seal shall extend to the bottom of the pavement. No shouldering shall be placed in the areas of the expansion joints until the vertical joint ends have been so sealed.

N4 Preformed E-8 Expansion Joint Sealer

The preformed material utilized for sealing the E-8 expansion joints shall be one of the following or an approved equal:

(A) "Pressure-Relief"

(B) "Eva Seal"

Material shall be installed according to the manufacturers recommendations.

O Blank

P Workmanship and Quality

P1a Surface Requirements

The Engineer will only accept pavement that meets the specified requirements within permissible tolerances for payment at the Contract bid prices. Pavement that fails to meet the minimum requirements when tested in the prescribed manner is considered defective. Defective pavement is subject to the provisions made herein for correction or adjusted payment. In addition, the concrete incorporated in the work is subject to 2461.

The Engineer will determine the limits of each individual defective pavement area and, when such areas are subject to price adjustment, the area is computed to the nearest whole square meter (**square yard**), except that areas of less that 1 m^2 (**square yard**) are considered 1 m^2 (**square yard**). The condition of each individual defective area of pavement is assessed based on the greatest deficiency within that area.

If any random or uncontrolled crack occurs in concrete pavement, the Engineer may require replacement of the pavement or portions thereof or require repairs and/or may require a reduced payment. If the Engineer

approves repair of the pavement, the Contractor shall repair the pavement using dowel load- transfer techniques listed in the latest Department's Rehabilitation Standards/Details. The Contractor shall submit to the Engineer for approval, the specific standard technique intended for repair. After approval by the Engineer, the Contractor shall perform replacement or repair work at no expense to the Department. The Contractor shall replace failed repairs at no expense to the Department. Acceptance of the repairs shall comply with the acceptance procedure for the pavement portion of the Project.

P1b Surface Smoothness

After completion of the initial curing period and prior to the opening of the roadway to traffic, the Contractor shall test the pavement surface for surface smoothness and ride quality. Surface Smoothness and Ride Quality shall be measured with a 7.62 m (**25 foot**) California type profilograph, or a Lightweight Inertial Profiler (IP), which produces a profilogram (profile trace of the surface tested). Either type of device must be certified according to the procedure on file in the Mn/DOT Concrete Engineering Unit. See 2301.3P1c to determined if ride quality is required.

The Contractor shall furnish a properly calibrated, documented, and certified 7.62 m (**25 foot**) wheel base, California type, computerized profilograph or Lightweight Inertial Profiler (IP) and competent operator in its' operation to measure pavement surface deviations in the longitudinal direction. The computer shall smooth the profile using a third-order Butterworth filter with a cutoff wavelength of 0.6096 m (**2.0 feet**). The computer shall generate a profile index using 0.2 inch blanking band and shall use a 7.62 mm (**0.3 inch**) bump threshold to identify "must grind" locations. Operate the profilograph in accordance with the manufacturer's instructions and at a speed no greater than a normal walk. Operate the IP at the optimum speed as defined by the manufacturer. To determine the profile index for mainline pavement, irregular pavement and ramps, make one pass in the right wheel path (2.7 m (**9 feet**) from center line). Run the profilograph or IP in the direction of driving traffic.

Make runs continuous and stop approximately 30 m (**100 feet**) prior to a construction header. Evaluate construction headers for smoothness on the next subsequent pass. Evaluate for smoothness all terminal headers that tie into existing pavement and the existing portland cement concrete pavement existing approximately 15 m (**50 feet**) adjacent to the terminal header. Bridge approach panels and bridge surfaces are exempt from these requirements; however, paving start-up areas are not exempt. Lift the test wheel and clearly label the profilogram to mark the beginning and end of each trace, each equation and each 152.4 m (**500 foot**) marker. Completely label each trace to show the Project number, stationing, lane, wheel pass, date paved, date tested and the operator's name. Make runs within 48 hours of pavement placement.

Turn over the profile index (California Test Method 526 on file) test results and the trace to the Engineer within 48 hours of each run. The trace shall include identification of all bumps and dips and the signature of the

operator. This data is also used for ride quality determination when required. The Engineer may test the entire Project length by a Mn/DOT certified independent source. If the Engineer determines that the Contractor's certified test results are inaccurate, the Contractor is charged for this work at a rate of $500 per lane 1.6093 km (**1 mile**), with a minimum charge of $1000.

When the profile trace shows a successive, uninterrupted bump, dip, or dip, bump combination (up to a maximum of 3 alternating trace deviations that relate to one bump or dip on the roadway), identify and evaluate these occurrences as one event.

In the longitudinal direction, determine deviations according to California Test Method 526. In the transverse direction, determine deviations using a 0.9144 m (**3 foot**) straight edge.

The Contractor shall correct all pavement areas represented by bumps having deviations of 7.62 mm (**0.3 inches**) or more in 7.62 m (**25 feet**) in the longitudinal direction, or 7.62 mm (**0.3 inches**) in 0.9144 m (**3 feet**) in the transverse direction using an approved texture planing grinding device consisting of multiple diamond blades.

Bumps between 7.62 mm (**0.3 inches**) and 10.16 mm (**0.4 inches**) may remain in place without correction or penalty in sections with a speed limit of greater than 68 km/h (**42 MPH**) if the ride is satisfactory in the judgment of the Engineer**.**

Bumps between 7.62 mm (**0.3 inches**) and 13 mm (**½ inches**) may remain in place without correction or penalty in sections with a speed limit of less than 68 km/h (**42 miles per hour**) if the ride is satisfactory in the judgment of the Engineer. For uncorrected bumps greater than 13 mm (**½ inches**) which the Engineer allows to remain inplace, the Engineer will assess a $900 penalty for each bump in each traffic lane.

If the Engineer orders, the Contractor shall correct all pavement areas represented by dips of 13 mm to 25 mm (**½ inch to 1.0 inch**) in 7.62 m (**25 feet**) in the longitudinal direction, or in 0.9144 m (**3 feet**) in the transverse direction by removal and replacement of the pavement or by using an approved texture planing grinding device consisting of multiple diamond blades. If the Engineer does not order corrective action, the Contractor is assessed a $900 penalty per lane for each uncorrected dip between 13 mm to 25 mm (**½ inch to 1.0 inch**). If dips exceed 25 mm (**1 inch**), the Contractor shall remove and replace the pavement.

At no cost to the Agency, the Contractor shall remove all bumps and dips described above, surface test and provide necessary additional corrective work to achieve the required surface smoothness or riding quality.

All costs relative to Contractor providing the profilograph and the appropriate profile index and traces are included in the unit bid price for 2301.502, Concrete Pavement, Standard Width and Item 2301.503, Concrete Pavement, Irregular Width.

P1c Ride Quality

The Engineer will determine the final ride quality based on the results of the California profilograph or IP data provided under 2301.3P1b as modified

herein. Paving Projects less than 0.8 km (**½ mile**) in continuous length and those portions of a paving project where the posted vehicle speed is anticipated to be less than 68 km/h (**42 miles per hour**), as determined by the Engineer are exempted from these riding quality requirements. The occurrence of bridges shall not interrupt the continuity determination, but the bridge surface and approach panels are not included in the ride quality determination. All pavements within 75 m (**250 feet**) of a terminal header that is not adjacent to a paved surface are exempt.

(1) Each lane is divided into 0.1609 km (**one-tenth mile**) sections and tested by the California profilograph or IP.

(2) Remaining subsections shorter than 0.1609 km (**one-tenth mile**) is tested according to (1) above, but is prorated for equivalency in the riding quality.

(3) Sections or subsections not excluded, which have riding quality greater than 63.13 mm/km (**4.00 in/mile**) but less than or equal to 94.70 mm/km (**6.00 in/mile**) as measured by the California profilograph or IP are accepted at the unit bid price.

(4) Sections or subsections not excluded, which have riding quality greater than 94.70 mm/km (**6.00 in/mile**) but less than or equal to 126.26 mm/km (**8.00 in/mile**) as measured by the California profilograph or IP are accepted at the unit bid price less a payment deduction determined according to Table 2301-P1.

(5) Sections or subsections that have a profile index greater than 126.26 mm/km (**8.00 in/mile**) will require removal and replacement or texture planing to a profile index of 94.70 mm/km (**6.00 in/mile**) or less at the Contractor's option. Sections or subsections that have a profile index greater than 94.70 mm/km (**6.00 in/mile**) may be texture planed to eliminate payment reductions. Planing to provide a bonus is not acceptable.

(6) Sections or subsections not excluded, which exhibit an exceptional riding quality less than 63.13 mm/km (**4.00 in/mile**), when tested by the California profilograph or IP, are paid at the unit bid price plus a bonus according to Table 2301-P1.

Table 2301-P1 (Metric)

2301.3P1c Profile Index – 0.2 Inch Blanking Band		
PI (millimeters per kilometer)	**Pay adjustment per 0.1 km segment**	**$ Per 0.1 km segment per lane (Lane width may vary)**
0.00 – 63.13	(63.13 – PI) X 7.762	$0.00 - $490.00
63.13 – 94.70	0	$0.00
94.70 – 126.26	$0.2195(PI)^2 – 55.43(PI) + 3062$	-$218.73 to -$437.41
>126.26	Corrective Action **	
**** Remove and Replace or Diamond Grind to a PI of 94.70 or less**		

Table 2301-P1 (English)

2301.3P1c Profile Index – 0.2 Inch Blanking Band		
PI (inches per mile)	**Pay adjustment per 0.1 mile Segment**	**$ Per 0.1 mile segment per lane (Lane width may vary)**
0.0 – 4.0	(4.0 – PI) X 197.12	$0.00 - $788.48
4.0 – 6.0	0	$0.00
6.0 – 8.0	$88(PI)^2 – 1408(PI) + 4928$	-$352.00 to -$704.00
>8.0	Corrective Action **	
**** Remove and Replace or Diamond Grind to a PI of 6.00 or less**		

The ride quality determination by the California profilograph method requires that the profilograph or IP is computerized to assimilate and store pavement profile data . All mainline pavement except those sections exempt above, are subject to (1) thru (6)above.

For easy review by the Engineer, the Contractor shall provide a profile index test summary report including the: station, length, square meters (**square yards**) represented, and price adjustment for each 0.1609 km (**one-tenth mile**) section. Adjacent lane results are reported in an adjacent column on the summary report.

No section or subsection will receive a riding quality bonus if more than 5 percent of the section or subsection is corrected by surface texture planing. Texture planed areas of sections are not eligible for incentive bonuses.

P2 Thickness Requirements

The finished pavement thickness will conform to the thickness shown in the Plans or as modified, in writing, by the Engineer. Modifications by the Engineer will be considered as being the plan thickness. Prior to the final acceptance of the work, the Contractor will core the pavement, as marked by the Department, for use as test specimens to verify the pavement thickness.

Coring will not begin until the new pavement has attained an age of 7 days or until control beams have attained a flexural strength of 3450 kPa (**500 pounds per square inch**). The Contractor will be responsible for filling the core holes with 3U18 concrete or another concrete mix approved by the Engineer. The Contractor will be responsible for all traffic control related to coring. All unacceptable cores and cores taken to delineate deficient pavement as outlined in 2301.3P2 or 2301.3P3 will be at the Contractor's expense. Coring will be in accordance with the following procedure:

The Engineer will calculate the number of cores required and their location using a random number procedure. The number of cores required will be calculated as follows:

(a) On each Project (and on each roadbed of a divided highway), main line pavement of each width, thickness and type will be divided into a series of 1500 m (**5,000 foot**) sections and one fractional section (or one fractional section if the total length is less than 1500 m (**5,000 feet**)), beginning at the point nearest the end of the Project shown in the Plans as the Beginning of the Project. Each loop and each ramp at each grade separation will be considered as one fractional section provided the thickness is the same; however a minimum of one core must be taken from each loop and/or ramp.

(b) One random core will be drilled from each 300 meter (**1,000 foot**) increment in each traffic lane of each 1500 meter (**5,000 foot**) section. In each fractional section over 150 meter (**500 feet**) in length, random cores will be drilled at the minimum rate of one core per 300 meter (**1,000 feet**) of traffic lane, but not less than a total of three cores.

(c) Selective cores may be taken as the Engineer directs, in addition to the random core program described above, but they will not be considered or used in computing the average thickness of acceptable pavement sections.

The Engineer will mark core locations on pavement and make any necessary location adjustments.

The Contractor will cut 100 mm (**4 inch**) nominal diameter cores at marked locations, other size cores will not be accepted. The cores will then be laid next to their holes in a curing condition (e.g., wrapped in wet burlap).

NOTE: If the age of the concrete pavement is older than 28 days, the cores will not be required to be stored in a curing condition. The Contractor will take precautions to ensure the quality of the cores. Cores that are out of round, have ridges, not perpendicular, etc. will not be accepted.

The Engineer will field measure the core thickness and verify (Field ID Number) the cores. Exploratory cores will be taken if the field measurements show any thin pavement, as described herein.

The contractor, accompanied by the Engineer, will pick up the cores and store them, in a curing condition (water tank, 15-25º C (**60-80ºF**)) if necessary, at the Department's field office.

The Contractor, accompanied by the Engineer, will transport the cores to the Mn/DOT's Office of Materials in a manner that will ensure their integrity. Examples of this would be to transport the cores in a bed of wet sand or to band the cores in a pyramid shape on a pallet, wet down and cover with plastic.

The contractor will be responsible for supplying all materials required for ensuring the integrity of the cores.

The pavement thickness will be determined by measuring the length of the cores in accordance with the procedure on file at the Office of Materials. This procedure provides for obtaining the average length of the core in one operation by the use of nine probes that are interconnected in a hydraulic linkage. The core length will be recorded to the nearest millimeter (**0.05 inch**).

Whenever any core shows a length deficiency of more than 10 mm (**½ inch**) from the planned thickness, exploratory cores will be taken. The first exploratory cores at any location will be taken 5 m (**10 feet**) on each side of the deficient core location and at the same distance from the pavement centerline, and one will be taken in the adjacent traffic lane if it was placed in the same operation. If the length of each one of the first exploratory cores is equal to or greater than the plan thickness of the pavement minus 10 mm (**½ inch**), no additional cores will be taken in that location. If any or all of these cores are not within such limitations, additional exploratory cores will be taken at intervals of 5 to 10 m (**10-25 feet**), as directed by the Engineer, at the same distance from the pavement centerline in the same lane as the original core. The coring will proceed in the direction of the deficiency until cores of satisfactory length are obtained.

Wherever the cores show a thickness deficiency greater than 10 mm (**½ inch**), the pavement will be considered to be defective. The defective pavement area will be considered as the entire area surrounding the deficient core (or cores) within a traffic lane and between acceptable cores. The remaining areas in an increment where the cores show a thickness deficiency no greater than 10 mm (**½ inch**) will be considered as acceptable pavement.

Where the cores are deficient in length by more than 10 mm (**½ inch**) and the concrete also has an air content less than 3.0 percent, the Contractor will remove and replace the defective pavement.

Where the cores are found to be deficient in length by more than 10 mm (**½ inch**) and the pavement represented by those cores is not required to be removed and replaced for other deficiencies, the Contractor may at his option either remove and replace the defective pavement or leave it in place in consideration of the payment deductions provided for herein, with the exception that the Engineer may order the removal and replacement of any pavement that is deficient in thickness by more than 25 mm (**1 inch**), in which case the following deductions will not apply.

Where the cores show a thickness deficiency exceeding 10 mm (**½ inch**), but less than 25 mm (**1 inch**), the pavement represented by those cores will not be excluded from the pay quantities; however, a deduction will be made from the moneys due the Contractor equal to the product of the defective areas and $25.00 per square meter (**$20.00 per square yard**). Pavement represented by cores showing a thickness deficiency of 25 mm (**1 inch**) or more will be excluded from all payments plus a deduction will be made from the moneys due the Contractor equal to the product of the defective areas and $25.00 per square meter (**$20.00 per square yard**). These deductions will be assessed in lieu of removing and replacing the areas of pavement which are deficient in thickness.

All acceptable random core lengths (not over 10 mm (**½ inch**) thickness deficiency) in each increment of a section or fractional section will be used to compute the average pavement thickness in each increment, except that where the length of any core exceeds the Plan thickness by more than 5 mm (**0.30 inch**), that core length will be limited to the Plan thickness plus 5 mm (**0.30 inch**). The average pavement thickness for each section or fractional section will be computed as the summation of the average thicknesses of the individual increments in the section or fractional section divided by the number of increments.

Whenever the average thickness of the acceptable pavement in a particular section or fractional section of the mainline pavement is found to be less than the Plan thickness by more than 3 mm (**0.10 inch**) or when the average thickness of the acceptable pavement in a fractional section of a Loop or Ramp is found to be less than the Plan thickness by more than 5 mm (**¼ inch**), the acceptable pavement in that section or fractional section (excluding any areas of defective pavement whether or not they have been removed and replaced acceptably) will be paid for at the Contract bid price, less a payment deduction determined in accordance with the following schedule:

TABLE 2301-3
DEDUCTIONS FOR THICKNESS DEFICIENCY

Thickness Deficiency Exceeding the Permissible Deviations	Deduction Per Square meter (**square yard**) of Payment
2 mm and below (**0.01 to 0.08 inch**, Incl.)	$0.20
Over 2 mm to 4 mm (**0.08 to 0.16 inch**, Incl.)	0.40
Over 4 mm to 6 mm (**0.16 to 0.24 inch**, Incl.)	0.60
Over 6 mm to 8 mm (**0.24 to 0.32 inch**, Incl.)	0.80
Over 8 mm to 10 mm (**0.33 to 0.40 inch**, Incl.)	1.00

3 mm (**0.10 inch**) for Mainline Pavement

5 mm (**¼ inch**) for Ramp or Loop Pavement, and for all Concrete Base

P3 Blank

2301.4 METHOD OF MEASUREMENT

Concrete pavement construction will be measured in terms of the several items of work as provided for herein, with all measurements being subject to adjustment as provided for in 2301.3P.

A Concrete Pavement

Concrete pavement will be measured by area based on the specified dimensions, including the area covered by integrant curb, and the area thus obtained will represent the surface area of the pavement as constructed. Irregular width pavement will be measured and paid for separately, if so indicated in the item name, but the pavement of every thickness and type will be included under the same item.

Included in the standard width measurement will be all uniform width pavement. Irregular width pavement will include all tapers and irregular shapes.

B Structural Concrete

Structural Concrete will be measured by volume based on the Plan thicknesses and the computed areas of concrete pavement. High early strength concrete sections will be measured separately only when and to the extent that separate compensation is provided therefor. Otherwise, the volumes of all pavement will be included in a single pay item, without regard to grade or strength of concrete or the type, width, and thickness of pavement.

C Pavement Reinforcement

Pavement reinforcement will be measured by area of pavement constructed with metal reinforcement. Areas will be measured separately by type of reinforcement as shown in the Plans, without regard to the number of layers used, and with no allowance for laps, splices, waste, and supporting devices.

D Expansion Joints

Expansion joints of each design designation, as detailed in the Plans, will be measured separately by length along the joint line.

E Reinforcement Bars

Reinforcement bars will be measured by mass (**weight**) prior to coating with epoxy, in accordance with 2472.4A. No measurement will be made under this item of those bars that are paid for as pavement reinforcement.

F Integrant Curb

Integrant curb of each design will be measured separately by length.

G Dowel Bars

Dowel bars will be measured by the actual number of individual dowels placed. No measurement will be made under this item for dowels that are paid for as a part of expansion joint construction.

H Bridge Approach Panels

When the Proposal contains an item (or items) for construction of bridge approach panels, their construction will be measured and paid for separately as complete in place items. Measurements will be as indicated in the

Proposal, either by the number of complete panels of each design, or by the total area of all panels of the same basic design. In the absence of such items, the panel construction will be measured for payment under the several items provided for pavement construction.

I Blank

J Concrete Coring

The Engineer will measure the number of cores designated in the Contract or ordered by the Engineer that are acceptably taken, identified, and delivered as required.

K Permanent Terminal Headers

Measurement will be made by the meter (**linear foot**) of terminal header constructed as specified

2301.5 BASIS OF PAYMENT

Payment for concrete pavement under 2301.501, 2301.502, or 2301.503, at the Contract bid prices per unit of measure will be compensation in full for all costs of constructing the pavement as specified, exclusive of those costs that are compensated for separately under other Contract items. The bid price includes all costs of fine grading, forming, spreading, screeding, finishing, curing, and protecting (the concrete, together with any other costs incidental to the pavement construction that are not covered by other items.

Payment for structural concrete at the Contract price per unit of measure will be compensation in full for all costs of producing, delivering, and depositing the concrete as specified, including all costs of the batch materials, mixing operations, and other incidentals involved in furnishing concrete for the work, except as otherwise provided by the following:

(a) Blank

(b) Blank

(c) High Early Concrete Mixes - Separate Pay Item: No extra compensation will be provided for the additional cement required in the production of high early strength concrete furnished as a separate pay item.

(d) High Early Concrete Mixes - Engineer's Ordered: In absence of a separate pay item for high early strength concrete, compensation will be provided in the amount of 20 percent above the Contract cubic meter (**yard**) price for standard strength concrete for the quantity ordered by the Engineer. The Contractor will also receive compensation for additional cement when the total cementitious exceeds 130% of the minimum cement content for the concrete mixture designation involved at a rate of invoice plus 15 percent. The Contractor shall also be compensated for the difference in cost of substituting cement for fly ash at the rate of the differences of the increased invoice costs plus 15 percent.

(e) Blank

(f) High Early Concrete Mixes – Contractor Requested, Engineer Approved: No extra compensation will be provided for high early strength concrete when requested by the Contractor.

Payment for pavement reinforcement of each type specified at the Contract prices per unit of measure of pavement in which the reinforcement is

placed will be compensation in full for all costs of furnishing and placing the metal reinforcement as specified, including all costs of tie wires, supporting devices, splicing, intermediate strike-off, and any other operations or materials incidental to furnishing and placing the reinforcement.

Payment for expansion joints of each design designation at the Contract price per unit of measure will be compensation in full for all costs of constructing the joints complete in place as detailed in the Plans, including the furnishing and placing of all required materials such as dowel bar assemblies, filler, and sealer materials.

Payment for dowel bars and reinforcement bars at the Contract prices will be compensation in full for all costs of furnishing and placing the materials as specified. No payment will be made under these items for those quantities that are compensated for on a complete unit basis as a part of other Contract items.

Payment for integrant curb at the Contract price per unit of measure for each design specified will be compensation in full for all costs of furnishing and placing the concrete, forming and finishing the curb, protecting and curing the concrete, and any other costs incidental to the completed curb.

Payment for construction of bridge approach panels at the Contract price per each panel complete in place, or at the Contract price per unit of measure for all panels, will be compensation in full for all costs of constructing the bridge approach panels as detailed in the Plans, including the costs of furnishing and placing concrete and steel, construction of integrant curb, terminal headers, concrete sills, protecting and curing the concrete, and other incidental work not specifically included for payment under other Contract items.

Payment for permanent terminal headers shall be compensation in full for all excavation, material and labor costs relative thereto.

The Department will pay the Contract unit price for each measured core. The Contractor shall accept this payment as compensation in full or all costs of material, labor, and equipment necessary to take the cores, deliver the cores as directed, fill core holes, provide traffic control, and provide other incidentals to the concrete coring.

Payment for concrete pavement construction will be made on the basis of the following schedule:

Item No.	Item	Unit
2301.501	Concrete Pavement	square meter (**square yard**)
2301.502	Concrete Pavement, Standard Width	square meter (**square yard**)
2301.503	Concrete Pavement, Irregular Width	square meter (**square yard**)
2301.511	Structural Concrete	cubic meter (**cubic yard**)
2301.513	Structural Concrete, HE (High Early Strength)	cubic meter (**cubic yard**)
2301.521	Pavement Reinforcement, Type__	square meter (**square yard**)

2301.529 Reinforcement Bars (Epoxy Coated)..... kilogram (**pound**)
2301.531 Expansion Joints, Design__..... meter (**linear foot**)
2301.538 Dowel Bar..... each
2301.541 Integrant Curb, Design__ ..... meter (**linear feet**)
2301.545 Concrete Coring ..... each
2301.551 Bridge Approach Panel..... each
2301.553 Bridge Approach Panels ..... square meter (**square yard**)
2301.561 Permanent Terminal Header.....meter (**linear foot**)
2301.562 Concrete Shoulder ..... square meter (**square yard)**

2321
Road-Mixed Bituminous Surface

2321.1 DESCRIPTION

This work shall consist of constructing one or more courses of road-mixed bituminous surfacing on a prepared base.

Subject to approval of the Engineer, hot plant mixtures conforming to 2360 may be substituted for the cold mixture provided for herein, in which case the mixing, spreading, and rolling shall be done in accordance with 2360, with compaction being in conformance with the ordinary compaction method as described therein.

2321.2 MATERIALS

A Aggregate

The aggregate shall conform to 2360 mixture type SPWEB240, With the exception that the aggregate for any course other than a wearing course may consist of Class 5 aggregate conforming to 3138 and the following modifications:

(1) Not less than 1 percent nor more than 7 percent of the aggregate shall pass the 75 µm (**# 200**) sieve.
(2) Within the specified gradation limits, the aggregate shall be uniform at the time of mixing.

If so requested by the Engineer, to determine quality and mixture proportions, representative production samples of the aggregate to be used in the production of wearing course mixture shall be submitted to the Materials Laboratory at least 15 days in advance of starting the wearing course mixture production.

B Bituminous Material..... 3151

The bituminous material for the mixture shall conform to the requirements for one of the following kinds and grades, subject to any limitations imposed by the Contract. If any options are permitted, the kind to be used shall be optional with the Contractor, but the grade shall be as designated by the Engineer.

MC Liquid Asphalt..... MC-250, 800
SC Liquid Asphalt..... SC-250, 800
Emulsified Asphalt..... SS-1, SS-1h, CSS-1h, CSS-1

C Anti-Stripping Additive..... 3161

If any additive is to be used, it may be added to the bituminous material at either the refinery or the job site. The blending shall be performed at a time and in a manner approved by the Engineer. When the additive is to be added on the job, the combined materials shall be mixed by not less than five complete circulations. No compensation in addition to the Contract prices will be made because of any additive that may be used.

2321.3 CONSTRUCTION REQUIREMENTS

A General

These requirements provide for the construction of a base course, a leveling course, a binder course, and a wearing course, or any combination thereof, and are based on methods of construction by which the bituminous material is be applied to and mixed with the aggregate by road-mixing methods or in a central mixing plant.

B Restrictions

Bituminous materials and mixtures shall not be applied to or placed on an untreated subgrade at any time when the moisture content of the top 75 mm (**3 inch**) of the subgrade is more than 65 percent of optimum moisture.

If emulsified asphalt is used for the mixture, the aggregate shall, at the time the emulsion is applied, contain sufficient moisture to ensure satisfactory mixing. (Note: This may require the addition of water.) If any other bituminous materials are used for the mixture, the aggregate shall not contain more than 2 percent of free moisture at the time the bituminous material is applied.

An anti-stripping additive may be used only with the consent of the Engineer. In this case, the aggregate may contain free moisture up to a maximum of 4 percent.

If mixing is performed on the road by blade-mix methods, the bituminous material shall be applied with distributors.

If the blade-mix method is employed, bituminous material shall be applied and mixing performed only during daylight hours and when the air temperature is 10ºC (**50º F**) or higher if the blade mix method is employed. The bituminous material shall be at least partially mixed with the aggregate before dark on the same day that it is applied.

If the mixing is performed by traveling plant or central mixing plant, it shall be performed when the air temperature is 4ºC (**40º F**) or higher.

Spreading and compacting shall be performed only during daylight hours and when the air temperature is 10ºC (**50º F**) or higher.

All mixtures shall be kept in windrows during rains and shall be free of surface moisture at the time of spreading and rolling operations.

The operations of depositing aggregates on the road, mixing aggregate with bituminous material, and spreading and rolling the mixture shall be conducted only on sections of such length as will meet the approval of the Engineer.

Each course shall be compacted and cured to such a degree that it will not be displaced or otherwise damaged before another course is placed thereon.

In general, no work within the roadbed will be permitted in the spring until seasonal load restrictions on roads in the vicinity have been removed. However, work within the roadbed may be permitted before that time if, in the opinion of the Engineer, it can be conducted without damage to the subgrade.

C Equipment

C1 Distributor

The distributor shall be so designed, equipped, maintained, and operated that bituminous material at even heat may be applied uniformly on variable widths of surface up to 4.5 m (**15 feet**) at readily determined and controlled rates up to 9.0 L (**2.0 gallons**) per square meter **(square yard)**, with uniform pressure, and with an allowable variation from any specified rate not to exceed 0.1 L (**0.02 gallon**) per square meter **(square yard)**. Distributor equipment shall include a tachometer, pressure gauges, accurate volume measuring devices or calibrated tank, and a thermometer for measuring temperatures of tank contents. Distributors shall be equipped with a power unit for the pump and full circulation spray bars adjustable laterally and vertically.

C2 Pneumatic-Tired Rollers

Pneumatic-tired rollers shall have a mass of not less than 3600 kg/m (**200 pounds per inch**) of rolling width. "Wobbly wheeled" rollers will not be permitted.

C3 Steel-Wheeled Rollers

Steel-wheeled rollers shall be of the self-propelled and have a minimum total mass of 7.3 metric tons (**8 tons**), or as otherwise specified in the Contract. When vibratory rollers are used, they shall produce 45 kN/m (**250 pounds per linear inch**) of width. The roller shall be capable of reversing without backlash and shall be equipped with spray attachments for moistening all rollers on both sets of wheels.

C4 Motor Graders

Motor graders shall be of the self-powered type, mounted on pneumatic tires. They shall be equipped with a blade not less than 3 m (**10 feet**) long and shall have a wheel base of not less than 4.5 m (**15 feet**). Motor graders used for the final layout and finishing of the surface shall be equipped with smooth pneumatic tires.

C5 Traveling Mixing Plants

The traveling plant shall be self-propelled and capable of maintaining a uniform rate of travel while mixing. It shall be mounted on pneumatic-tired wheels or smooth tread crawler tracks of such size that the underlying road surface will not be rutted or damaged when the plant is loaded to capacity. The plant shall be so designed and constructed that it will pick up all of the aggregate cleanly from the road without damaging the underlying road surface.

The traveling plant shall be capable of constantly measuring the bituminous material accurately, mixing it thoroughly with the aggregate, and depositing the mixture in a uniform windrow.

The traveling plant shall be equipped with sufficient valves and a stub pipe in the bitumen line between the pump and the spray bar to facilitate calibration of the output of the pump. They shall also be equipped with temperature and metering devices that will determine accurately the temperature and quantity of bituminous material being applied to the aggregate.

C6 Central Mixing Plants

When heating of the aggregate is not required, central mixing plants may be of any type that will produce a bituminous mixture conforming to the mix requirements of this Specification. However, as minimum requirements, the plant shall be equipped with temperature and metering devices that will determine accurately the temperature and quantity of bituminous material being applied to the aggregate. Feeding of the aggregate and bituminous materials into the mixer shall be synchronized by interlocking mechanical means or other positive method approved by the Engineer.

D Treatment of the Surface

D1 Prime Coat

If so indicated in the Plans or directed by the Engineer, a bituminous prime coat shall be applied to the prepared base in accordance with 2358 prior to placement of the first course of bituminous mixture.

D2 Tack Coat

A bituminous tack coat shall be applied to existing bituminous or concrete surfaces and to the surface of each course constructed other than the final course, with the application being done in accordance with 2357 prior to placement of the next course thereon.

E Depositing and Mixing Aggregate with Bituminous Material

After satisfactory absorption of the prime coat, if used, the required quantity of new aggregate shall be deposited on the road. The new aggregate and float aggregate, if used, shall be thoroughly mixed and then bladed into a single windrow of uniform cross section for measurement and adjustment as directed by the Engineer.

If the mixing is performed by the road-mix method or by a traveling plant that depends on a uniform forward speed to measure the aggregate windrow, a windrow proportioner (evener) shall immediately precede the mixing operations. The windrow shall be evened or shaped until all measured cross-sections taken at 30 m (**100 foot**) intervals are not less

than 95 percent or more than 105 percent of the average of all measured cross sections for the portion of the windrow involved.

If, on any portion of the Project, the base course is required to carry traffic during the interim period between its completion and the construction of the next course thereon, the bitumen content of the mixture for the base course on that section of the roadbed may be increased, at the option and direction of the Engineer, beyond the maximum limits provided above, but not to exceed the maximum application rate for wearing course mixtures.

The bituminous material shall be applied to the aggregate at a total rate designated by the Engineer, within the following limits:

TABLE 2321-1
BITUMINOUS APPLICATION RATE

Kind of Bituminous Material	Rate in Liters per Metric Ton (Gallons/ton) of Dry Aggregate	
	Base, Leveling Binder Courses	Wearing Course
SC	---	42 to 58 (**10 to 14**)
MC	33 to 46 (**8 to 11**)	42 to 58 (**10 to 14**)
SS, CSS	42 to 58 (**10 to 14**)	50 to 75 (**12 to 18**)

If the method of mixing employs equipment requiring the bituminous material to be applied in a separate operation, no single application of bituminous material shall be applied to the aggregate in a quantity exceeding 2.3 L/m^2 (**½ gallons per square yard**). The number and rate of applications shall be as directed by the Engineer. After each application, the bituminous material and aggregate shall be mixed sufficiently to produce a mixture of uniform color and, after the last application, the mixing shall continue until all particles of the aggregate are thoroughly coated and the mixture is free from fat or lean spots, balls, and uncoated particles.

The temperature of the bituminous material at the time of application shall be as approved by the Engineer, within the limits specified below:

TABLE 2321-2
TEMPERATURE OF BITUMINOUS MATERIAL

Liquid Asphalt	MC-250, SC-250	40-105ºC **(105-220ºF)**
	MC-800, SC-800	60-125ºC **(135-255ºF)**
Emulsified Asphalt	SS-1, SS-1h,	20 to 70ºC **(70 to 160ºF)**
	CSS-1, CSS-1h	20-70ºC **(70-160ºF)**

During the application of bituminous material, the changing of speed or the shifting of gears will not be permitted.

F Spreading

Before spreading the mixture, aeration by manipulation will be required until the mixture has become tacky and free of surface moisture to a degree satisfactory to the Engineer.

The bituminous mixture shall be spread without segregation to produce a layer of uniform thickness and the specified cross section.

The contact surface of curbs, concrete pavements, or other fixed structures shall be painted with a thin uniform coat of liquid bituminous material just before any bituminous mixture is placed against them.

After final compaction, all bituminous surfaces adjacent to gutters, manholes, pavement headers, or other fixed structures shall be slightly higher (but not to exceed 6 mm (**¼ inch**)) than the surface of such structures.

G Rolling

Rolling shall begin at the time the mixture is being spread and continue until after the mixture has been shaped to the required cross-section.

Each course shall be thoroughly and uniformly compacted for its full thickness with pneumatic-tired rollers traveling at speeds not to exceed 8 km/h (**5 miles per hour**). The final rolling on the last course constructed under the Contract shall be performed with steel wheeled rollers traveling at speeds not to exceed 5 km/h (**3 miles per hour**). The rolling shall begin at the lower edge of the course and progress toward the upper edge or centerline. Each pass of the roller shall overlap the preceding pass by at least half the width of the roller and shall terminate at least 1 m (**3 feet**) in advance of or to the rear of the termination of the preceding pass.

The entire surface shall be rolled until there is no further compaction and until all roller marks are eliminated. Rolling shall be discontinued whenever it begins to produce excessive crushing or pulverizing of the aggregate or displacement of the mixture. In places inaccessible to the roller, compaction equal to that obtained with rollers shall be secured by means of mechanical tampers.

As necessary to prevent adhesion of the mixture to the roller wheels, the contact surfaces of the wheels shall be kept properly moistened, using water or a water solution containing small quantities of detergent or other approved material.

During the final spreading and compacting operations on each course, the Contractor shall check the thickness and surface for conformance with the thickness and surface requirements specified in 2321.3H. Any area that does not conform may be corrected by loosening the compacted surface, adding more mixture or reshaping the mixture, and recompacting. Lean, fat, or segregated areas shall be removed and replaced with new material. All corrections shall be made at no expense to the Department.

H Thickness and Surface Requirements

After compaction, the finished surface of any course shall show no variation greater than 6 mm (**¼ inch**) from the edge of a 3 m (**10 foot**) straightedge laid thereon parallel to the centerline.

After compaction, the alignment of the outside edges of any course shall be such that the distance between the edge and the established centerline shall not vary more than 75 mm (**3 inches**) from the distance shown in the Plans for that course.

After compaction, no portion of any course other than a leveling course shall vary from the thickness shown in the Plans for that course by more than 13 mm (**½ inch**). No individual test shall show a thickness deficiency of more than 13 mm (**½ inch**). On any area where tests show a thickness in excess of the Plan thickness plus 13 mm (**½ inch**), the Department reserves the right to exclude from the final pay quantities the materials used in the excess mixture, above that required to construct the course in that area to a thickness equal to the Plan thickness plus 13 mm (**½ inch**).

I Blank

J Seal Coat

When specified in the Contract or ordered by the Engineer, designated areas of the finished surface shall be given a light bituminous seal coat in accordance with 2356.

If the Contract does not provide for application of a seal coat with cover aggregate, or if weather conditions at the time the seal coat would be applied in the normal sequence of operations do not permit its application at the time, the Contractor shall apply a fog seal if the Engineer so directs, using bituminous material of any kind and grade approved by the Engineer. Slow curing liquid asphalt will not be approved for use as fog seal material. The time and rate of application shall be as directed by the Engineer, with the rate of application not to exceed ½ L/m^2 (**0.1 gallon per square yard**).

2321.3

K Aggregate in Stockpiles

When the Contract contains an item for stockpile aggregate, the Contractor shall, in addition to the aggregate required for the bituminous surfacing, produce and deliver aggregate of the class specified to the Department at the designated sites. Delivery shall be made when and as approved by the Engineer. Construction of stockpiles shall be as directed by the Engineer.

2321.4 METHOD OF MEASUREMENT

A Aggregate

Aggregate will be measured, as indicated in the Proposal, by mass or LV of material deposited on the road. When mixing is performed in a hot-mix plant, the measured weights will include the weight of the bituminous material incorporated into the mixture.

B Bituminous Material

Bituminous materials will be measured by volume. Bituminous material used for fog seal will be measured and included for payment with the measured quantity of bituminous material for mixture.

C Stockpile Aggregate

Stockpile aggregate of each class specified will be measured as indicated in the Proposal, by mass or loose volume of material delivered in stockpiles.

2321.5 BASIS OF PAYMENT

Payment for the accepted quantities of aggregate and bituminous material incorporated in the mixture at the Contract prices per unit of measure will be compensation in full for all costs of constructing the bituminous surfacing as specified.

Payment for stockpile aggregate of each class specified, at the Contract prices per unit of measure, will be compensation in full for all costs of producing and delivering the material to the Department at the designated sites, including all costs of constructing the stockpiles as specified.

Payment for the road-mixed bituminous surface will be made on the basis of the following schedule:

Item No.	Item	Unit
2321.503	Bituminous Material for Mixture	liter (**gallon**)
2321.506	Aggregate	metric ton (**ton**)
2321.507	Aggregate	cubic meter (**cubic yard**)
2321.511	Stockpile Aggregate, Class___	metric ton (**ton**)
2321.513	Stockpile Aggregate, Class ___	cubic meter (**cubic yard**)

2350 (deleted)

2355
Bituminous Fog Seal

2355.1 DESCRIPTION

This work shall consist of treating an existing bituminous pavement to seal the surface.

2355.2 MATERIALS

A Bituminous Material..... 3151

The bituminous material for fog seal shall be one of the following kinds and grades conforming to 3151.

RC liquid Asphalt..... RC-70
Emulsified Asphalt
Anionic SS-1, SS-1h
Cationic..... CSS-1, CSS-1h

2355.3 CONSTRUCTION REQUIREMENTS

A Restrictions

Fog seal operations shall be conducted in a manner that will offer the least inconvenience to traffic, with movement in at least one direction permitted at all times without pickup or tracking of the bituminous material.

The fog seal shall not be applied until the road surface and weather conditions are acceptable to the Engineer.

For air temperatures greater than 4ºC (**40 ºF**), asphalt emulsion shall be used unless it is no longer available for the season. When conditions require that liquid asphalt (RC-70) be used, the Engineer may require a light application of sand to prevent material pickup or tacking.

B Equipment

The bituminous material shall be applied with a distributor meeting the requirements of 2321.3C1.

C Road Surface Preparations

At the time of applying bituminous material, the road surface shall be dry and clean, and all necessary repairs or reconditioning work shall have been completed as provided in the Contract.

All objectionable foreign matter on the road surface shall be removed and disposed of by the Contractor as approved by the Engineer.

D Application of Bituminous Material

The bituminous material shall be applied at a uniform rate of

(1) 0.45 to 0.70 L/m^2 (**0.10 to 0.15 gallon per square yard**) for diluted asphalt emulsion, or,
(2) 0.45 L/m^2 (**0.10 gallon per square yard**) for RC-70 cutback asphalt.

The time and rate of application shall be as directed by the Engineer.

The temperature of the bituminous material at the time of application shall be as directed by the Engineer, within the limits specified below:

Liquid Asphalt RC-70 ..... 50 to 80ºC (**120-175ºF)**
Emulsified Asphalt
SS-1, SS-1h, CSS-1, CSS-1h.....20 to 70ºC (**120-175ºF**)

The asphalt emulsion shall be diluted with water, 50 percent by volume, to improve the material application and distribution characteristics. However, the added water will be excluded from the pay quantities.

Sand shall be spread on the newly fogged surface at pedestrian crossings unless otherwise directed by the Engineer.

2355.4 METHOD OF MEASUREMENT

A Bituminous Material

Bituminous material used for fog seal will be measured by volume at 15ºC (**60 ºF**).

2355.5 BASIS OF PAYMENT

Payment for the accepted quantity of bituminous material used for fog seal at the Contract price per unit of measure will be compensation in full for all costs of furnishing and applying the material as specified.

Furnishing and applying sand on the newly fogged surfaces shall be at no expense to the Department.

Payment for fog seal will be made on the basis of the following schedule:

Item No.	Item	Unit
2355.502	Bituminous Material for Fog Seal	liter (gallon)

2356
Bituminous Seal Coat

2356.1 DESCRIPTION

This work shall consist of an application of bituminous material followed by an application of cover aggregate on designated areas of an existing bituminous pavement.

2356.2 MATERIALS

A Bituminous Material.....3151

The bituminous material for seal coat shall be one of the following kinds and grades conforming to 3151. When the Contract quantity exceeds 7500 L (**2000 gallons**) , and unless other options are permitted by the Plans or Special Provisions, the kind to be used shall be emulsified asphalt, cationic grades. In all cases the grade to be used shall be as designated by the Engineer.

RC Liquid Asphalt..... RC-250, 800, 3,000
Emulsified Asphalt,
Anionic RS-1, RS-2
Cationic CRS-1, CRS-2
Asphalt Cement ..... (penetration as specified)

B Seal Coat Aggregate 3127

The class of aggregate to be used will be shown in the Plans or indicated in the Special Provisions.

C Anti-Stripping Additive..... 3161

All bituminous material, except emulsions, shall be treated with an approved anti-stripping additive used in such quantity that the treated bituminous material will meet the pertinent requirements of 3161. The additive shall be added to the bituminous material at the refinery in a manner approved by the Engineer.

2356.3 CONSTRUCTION REQUIREMENTS

A Restrictions

Seal coating operations (including traffic restrictions on the freshly constructed seal coat) shall be conducted:

(1) Not before May 15 nor after August 31;
(2) Only during daylight hours;
(3) When the pavement and air temperature are 20ºC (**70ºF**) or higher;
(4) When the relative humidity is less than 75 percent; and
(5) When the road surface is dry and clean.

The seal coating operations shall not be started, and shall be suspended, when any one of the above conditions cannot be met.

B Equipment

B1 Distributor

The bituminous material shall be applied with a distributor meeting the requirements of 2321.3C1.

B2 Aggregate Spreader

The cover aggregate shall be applied with an approved mechanical type aggregate spreader that is capable of distributing the aggregate uniformly to the required width and at the designated rate, with the application sharply defined at the edges.

The aggregate spreader shall be a self-propelled type mounted on pneumatic-tired wheels that are so located as to operate on the freshly applied aggregate.

B3 Pneumatic-Tired Roller

The pneumatic-tired roller shall have a compacting width of 1.5 m (**5 feet**) or more and shall be so constructed that the gross mass of not less than 3500 kg/m (**200 pounds per inch**) of rolling width can be varied as directed by the Engineer. The tire arrangement shall

be such that full compaction will be obtained over the full width with each pass of the roller.

The roller may be self propelled or provided with suitable tractive equipment, unless the Contract specifies a certain type. If more than one roller propelled by a single tractive unit, the combination will be counted as a single roller unit.

B4 Paver Brooms

A rotary power broom shall be provided that is capable of cleaning the road surface prior to spraying bituminous material and to remove loose particles after treatment as required.

C Road Surface Preparations

At the time of applying bituminous material, the road surface shall be dry and clean, and all necessary repairs or reconditioning work shall have been completed as provided for in the Contract.

All objectionable foreign matter on the road surface shall be removed and disposed of by the Contractor as the Engineer approves.

When specified in the Contract or ordered by the Engineer, a tack coat shall be applied to the prepared road surface in accordance with 2357.

D Application of Bituminous Seal Material

Application of bituminous material shall be governed by the rate at which the cover aggregate is applied and by the provisions made for maintenance of traffic. No traffic shall be permitted on uncovered bituminous material.

Bituminous material shall not be applied until the loaded aggregate spreader is on hand ready to begin application of aggregate immediately, with sufficient truck loads of aggregate at the site to cover the length of the anticipated applications of bituminous material.

The bituminous material for seal coat shall be applied to the road surface at a rate designated by the Engineer, within the limits specified below for the class of aggregate to be used.

TABLE 2356-1
SEAL COAT APPLICATION RATE
Liters per Square Meter
(Gallons per Square Yard)

Aggregate	Emulsified or Liquid Asphalts	AsphaltCement
FA-1	0.68-0.91 (**0.15 - 0.20**)	-
FA-2	0.68-1.1 (**0.15 - 0.25**)	-
FA-3	0.91-1.6 (**0.20 - 0.35**)	0.59-0.82 (**0.13 - 0.18**)
FA-4	1.4-2.0 (**0.30 - 0.45**)	0.68-0.91 (**0.15 - 0.20**)
FA-5	1.8-2.3 (**0.40 - 0.50**)	2.0-2.5 (**0.45 - 0.55**)

To prevent overlapping at the end junction at transverse joints, means shall be provided to ensure positive cutoff for the bituminous material and cover aggregate. A section of building paper or other suitable material shall be placed across the lane to be coated and be positioned so that the forward edge is at the desired joint location. The distributor, traveling at the correct speed, shall start spraying on the building paper so that when the exposed surface is reached, the spray will be full and uniform. The same procedure shall apply to cover aggregate placement. The masking material used shall be removed and be disposed of in a manner approved by the Engineer.

Application of the bituminous material shall produce a uniform film without ridges and skips. Adjustments to the spray bar and nozzles shall be made prior to application of the bituminous material on the areas to be sealed.

The temperature of the bituminous material at the time of application shall be as approved by the Engineer, within the limits specified below:

Asphalt Cement		175°C (**350 ºF**) Max.
RC Liquid Asphalt	RC-250	74 to 105°C (**165 to 220º F**)
	RC-800	93 to 107°C (**200 to 225º F**)
	RC-3000	110 to 145°C (**230 to 290º F**)
Cationic Emulsified Asphalt	CRS-1,2	52 to 85°C (**125 to 185º F**)
Anionic Emulsified Asphalt	RS-1	21 to 60°C (**70 to 140º F**)
	RS-2	52 to 85°C (**125 to 185º F**)

E Application of Cover Aggregate

The cover aggregate shall be spread immediately following the application of bituminous material. Under no circumstances shall operations proceed in such manner that the bituminous material remains uncovered for more than 1 minute so as to set-up or dry-out to an extent that will impair retention of the cover aggregate.

The aggregate, at the time of spreading, shall not contain more than 2 percent (by mass) of free surface moisture, except that when FA-1 aggregate or an asphalt emulsion is used, the aggregate shall contain not more than 4 percent of free surface moisture.

The aggregate shall be spread uniformly over the full width of the bituminous application, at a rate designated by the Engineer, within the range of 20 to 25 kg/m^2 (**40 to 50 pounds per square yard**) when FA-5 aggregate is used, or at the rate of 14 kg (**100 pounds**) of aggregate for each liter (**gallon**) of bituminous material used, per square meter (**square yard**).

To determine the volumetric rate of application, the mass per volume (truck measure) shall be determined by weighing a measured truck load on a scale furnished or made available by the Contractor.

Immediately after spreading the cover aggregate, any areas having non-uniform coverage shall be corrected to the satisfaction of the Engineer by removing excess material and spreading additional material over deficient areas. Variations in coverage exceeding 10 percent of the designated rate of application shall be corrected as ordered.

F Rolling Operations

Initial rolling shall follow immediately behind the spreading of cover aggregate, with the initial coverage completed within 5 minutes after spreading the aggregate. The surface rolling shall be continued until five complete coverages over the full width have been obtained. All rolling operations on an area shall be completed within 30 minutes after spreading the cover aggregate on that area.

All rolling shall be performed with approved self-propelled, smooth-tread pneumatic-tired rollers. A minimum of two rollers shall be used for rolling operations. The rollers shall not be operated at speeds exceeding 8 km/h (**5 miles per hour**). Rolling shall begin at the outer edge of the aggregate cover and proceed in a longitudinal direction, working toward the center of the road.

The completed surface shall present a uniform appearance. The surface shall be lightly broomed or otherwise maintained as necessary during the rolling operations to achieve uniform appearance.

G Protection of the Surface

No traffic shall be permitted on the sealed road surface until after all rolling has been completed and the bituminous material has set to a degree satisfactory to the Engineer and will not pick up on vehicle tires.

In addition to other barricades and warning signs required by the Contract, the Department will furnish and deliver to the Project such other barricades and warning signs as the Engineer deems necessary for use in conjunction with the seal coat construction. The Contractor shall erect and maintain those barricades and signs at locations directed by the Engineer**.**

The Contractor shall furnish traffic cones at least 450 mm (**18 inches**) in height and place them at intervals of not more than 60 m (**200 feet**) on the inner longitudinal edge of the freshly applied seal coat. These cones shall be maintained in place until the road is opened to unrestricted use by traffic.

When the road under construction is open to traffic during daylight hours, the Contractor shall furnish a minimum of two flagpersons and a pilot vehicle to direct and guide traffic through the construction zone. One flagger shall be stationed in advance of the seal coat operations and another at the rear barricade at the beginning of the uncovered bituminous material. It shall be the duty of the flagger to stop all traffic and to acquaint the traveling public with the nature of the work underway, the limitations on the road surface available for traffic use, and the reason for reduced driving speed.

The contractor shall provide a Traffic Control Plan consistent with the "Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) and approved by the Engineer."

On the morning following each day of seal coat operations, the Contractor shall sweep the surplus aggregate from the previous day's seal coat construction. This operation shall be conducted while the road surface is still cool, and care shall be exercised that the aggregate that has set is not disturbed. Where sealing is done in municipalities, the Contractor shall dispose of the surplus aggregate in a manner satisfactory to the Engineer.

2356.4 METHOD OF MEASUREMENT

A Bituminous Material

Bituminous material applied on the road will be measured by volume at 15°C (**60° F**).

B Seal Coat Aggregate

Seal coat aggregate will be measured as indicated in the Proposal, by mass or LV of material deposited on the road.

2356.5 BASIS OF PAYMENT

Payment for the accepted quantities of bituminous material (including any required additives) and seal coat aggregate at the appropriate Contract prices will be compensation in full for all costs of constructing the seal coat as specified.

Payment for the bituminous seal coat will be made on the basis of the following schedule:

Item No.	Item	Unit
2356.505	Bituminous Material for Seal Coat	liter (**gallon**)
2356.507	Seal Coat Aggregate	metric ton (**ton**)
2356.509	Seal Coat Aggregate (LV)	cubic meter (**yard**)

2357
Bituminous Tack Coat

2357.1 DESCRIPTION

This work shall consist of treating an existing bituminous or concrete surface with bituminous material preparatory to placing a bituminous course or seal coat thereon.

2357.2 MATERIALS

A Bituminous Material..... 3151

The bituminous material for tack coat shall be one of the following kinds and grades conforming to 3151. When the Contract quantity exceeds 7500 L (**2000 gallons**), and except during periods of freezing temperatures, the tack coat material to be used will be limited to one of the kinds of emulsified asphalt. Otherwise, the kind to be used shall be optional with the Contractor. The grade to be used shall be as designated by the Engineer.

MC liquid Asphalt..... MC-250,800
RC Liquid Asphalt..... C-70, 250, 800
Emulsified Asphalt,
Anionic SS-1, SS-1H, MS-2, RS-1, RS-2
Cationic CSS-1, CSS-1H, CRS-1, CRS-2

2357.3 CONSTRUCTION REQUIREMENTS

A Restrictions

Tack coat operations shall be conducted in a manner that offers the least inconvenience to traffic, with movement in at least one direction permitted at all times without pickup or tracking of the bituminous material. The tack coat shall not be applied when the road surface or weather conditions are unsuitable. The daily application of tack coat shall be limited to approximately the area on which construction of the subsequent bituminous course can reasonably be expected to be completed that day.

B Equipment

The bituminous material shall be applied with a distributor meeting the requirements of 2321.3C1.

C Road Surface Preparations

At the time of applying bituminous material, the road surface shall be dry and clean, and all necessary repairs or reconditioning work shall have been completed as provided for in the Contract.

All objectionable foreign matter on the road surface shall be removed and disposed of by the Contractor as the Engineer approves.

Preparatory to placing an abutting bituminous course, the contact surfaces of all fixed structures and the edge of the in-place mixture in all courses at transverse joints and in the wearing course at longitudinal joints shall be given a uniform coating of liquid asphalt or emulsified asphalt, applied by methods that will ensure uniform coating.

D Application of Bituminous Material

The bituminous material shall be applied at a uniform rate not to exceed:

(1) 0.23 L/m^2 (**0.05 gallon per square yard**) for cutback asphalt and undiluted asphalt emulsion (as supplied from the refinery).

(2) 0.91 L/m^2 (**0.20 gallon per square yard**) for diluted asphalt emulsion (with water added in the field).

The time and rate of application shall be as directed by the Engineer.

The temperature of the bituminous material at the time of application shall be as approved by the Engineer, within the limits specified following:

Liquid Asphalt	RC-70	49 to 82°C (**120 to 180° F**)
	RC-250, MC-250	74 to 104°C (**165 to 220° F**)
	RC-800, MC-800	93 to 124°C (**200 to 255° F**)
Emulsified Asphalt	SS-1, SS-1H, MS-2, CSS-1, CSS-1H	21 to 71°C (**70 to 160° F**)
	RS-1	21 to 60°C (**70 to 140° F**)
	5S-2, CRS-1, CRS-2	52 to 85°C (**120 to 185° F**)

For asphalt Grades SS-1, SS-1H, CSS-1, and CSS-1H, water may be added up to 50 percent by volume to improve the material application and distribution characteristics. However, the added water will be excluded from the pay quantities.

Unless otherwise directed, sand shall be spread on the newly tacked surface at pedestrian crossings.

2357.4 METHOD OF MEASUREMENT

A Bituminous Material

Bituminous material used for tack coat will be measured by volume at 15ºC (**60º F**)

2357.5 BASIS OF PAYMENT

Payment for the accepted quantity of bituminous material used for tack coat at the Contract price per unit of measure will be compensation in full for all costs of furnishing and applying the material as specified.

Furnishing and applying sand on newly tacked surfaces at pedestrian crossings shall be at no expense to the Department with no direct compensation being made therefore.

Should the Contract fail to include a Contract Item covering payment for the bituminous material used for tack coat, all costs of furnishing and applying bituminous tack coat material will be included in the compensation provided for the bituminous mixture, with no measurement made of the bituminous material used and with no direct compensation being made therefor.

Payment for the tack coat will be made on the basis of the following schedule:

Item No.	Item	Unit
2357.502	Bituminous Material for Tack Coat	liter (**gallon**)

2358
Bituminous Prime Coat

2358.1 DESCRIPTION

This work shall consist of treating a prepared base with bituminous material preparatory to placing a bituminous course thereon.

2358.2 MATERIALS

A Bituminous Material.....3151

The bituminous material for the prime coat shall conform to the requirements for one of the following kinds and grades, subject to any limitations imposed by the Contract. If any options are permitted, the kind to be used shall be optional with the Contractor but the grade shall be as designated by the Engineer.

MC Liquid Asphalt MC-30, 70

2358.3 CONSTRUCTION REQUIREMENTS

A Restrictions

Bituminous prime coat shall not be applied at any time when the moisture content of the upper 80 mm (**3 inches**) of the base is more than 65 percent of optimum moisture, or when the weather or road surface conditions are otherwise unsuitable for proper construction.

When traffic is being maintained over the section of road under construction, not more than 50 percent of the traveled way shall be closed to traffic at any one time, and traffic movement in at least one direction shall be permitted at all times without pick up or tracking of the bituminous material.

B Equipment

The bituminous material shall be applied with a distributor meeting the requirements of 2321.3C1.

C Road Surface Preparations

At the time of applying the bituminous material, the subgrade shall be in acceptable condition, with all preparation and maintenance operations completed as required by other provisions of the Contract.

D Application of Bituminous Material

The bituminous material shall be applied in a uniform, continuous spread at the rate of 0.45 to 1.35 L per square meter (**0.1-0.3 gallons**) and in one or two applications, as directed by the Engineer.

Care shall be taken that the application of bituminous material at the junction of spreads is not in excess of the specified quantity. Excess bituminous material shall be squeegeed from the surface. Skipped areas and deficiencies shall be corrected.

The temperature of the bituminous material at the time of application shall be as approved by the Engineer, within the limits specified below.

MC Liquid Asphalt	MC-30.....	29 to 63°C (**85 to 145° F**)
	MC-70.....	49 to 82°C (**120 to 180° F**)

2358.4 METHOD OF MEASUREMENT

A Bituminous Material

Bituminous material for prime coat will be measured by volume at 15°C (**60° F**).

2358.5 BASIS OF PAYMENT

Payment for the accepted quantity of bituminous material used for prime coat at the Contract price per unit of measure will be compensation in full for all costs of furnishing and applying the material as specified, exclusive of those costs which are to be compensated for separately under other Contract items.

Payment for the prime coat will be made on the basis of the following schedule.

Item No.	**Item**	**Unit**
2358.501	Bituminous Material for Prime Coat	liter (**gallon**)

2360
Plant Mixed Asphalt Pavement

2360.1 DESCRIPTION

This work consists of the construction of one or more pavement courses of hot plant mixed asphalt-aggregate mixture on the approved prepared foundation, base course or existing surface in accordance with the specifications and in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the Engineer. Mixture design will be either 2360 or 2350 (gyratory or Marshall) as described in the Special Provisions through the mixture designation.

A Mixture Designations

Mixture designations for asphalt mixtures contain the following information:

(1) The first two letters indicate the mixture design type:
- SP = Gyratory Mixture Design
- LV = Marshall Mixture Design – Low Volume, 50 blow
- MV = Marshall Mixture Design – Medium Volume, 50 blow
- SM = Gyratory Mixture Design for Stone Matrix Asphalt (SMA)

(2) The third and fourth letters indicate the course:
- WE = Wearing and Shoulder Wearing Course
- NW = Non-Wearing Course

(3) The fifth letter or number indicates the maximum aggregate size*:
- A or 4 = 12.5mm (**½ inch**), SP 9.5 mm (**3/8 inch**)**
- B or 3 = 19.0mm (**¾ inch**), SP 12.5 mm (**½ inch**)**
- C or 2 = 25.0mm (**1 inch**), SP 19.0 mm (**¾ inch**)**
- 5 = 9.5mm (**3/8 inch**), 4.75 mm (**#4**) nominal size (Marshall design only)
- E = See provision for SMA design
- * Letter is used in gyratory designation; number is used in Marshall designation
- ** Nominal maximum aggregate size

(4) **For Gyratory Design**:

The sixth digit indicates the Traffic Level (ESAL's x 10^6)

The requirements for gyratory mixtures in this specification are based on the 20-year design traffic level of the Project expressed in Equivalent Single Axle Loads (ESAL's). The five traffic levels are shown below in Table 2360.1-A.

TABLE 2360.1-A
TRAFFIC LEVELS

Traffic Level	20 Year Design ESAL's (1×10^6 ESAL's)
2[1]	<1
3[2]	1 to < 3
4	3 to < 10
5	10 to ≤ 30
6	SMA

1 – (AADT≤ 2300)
2 – (2300 < AADT < 6000)

For Marshall Design:

The sixth and seventh digit indicate the Marshall design blows:

50 blow design for both LV and MV mixtures

(5) The last two digits indicate the air void requirement:

40 = 4.0% for SP and SM Wear mixtures
35 = 3.5% for MV Wear and Non-Wear
30 = 3.0% for LV Wear and Non-Wear and SP Non-Wear and Shoulder

(6) The letter at the end of the mixture designation identifies the asphalt binder grade:

A = PG 52-34
B = PG 58-28
C = PG 58-34
D = PG 58-40
E = PG 64-28
F = PG 64-34
G = PG 64-40
H = PG 70-28
I = PG 70-34
L = PG 64-22

Ex: Gyratory Mixture Designation -- SPWEB540E (Design Type, Lift, Agg Size, Traffic Level, Voids, Binder)
Ex: Marshall Mixture Designation – LVWE35030B (Mix Type, Lift, Agg Size, Marshall blows, Voids, Binder)
Ex: SMA Mixture Designation -- SMWEE640H (Design Type, Lift, Agg Size, Traffic Level, Voids, Binder)

B Minimum Lift Thickness

Minimum paving lift thickness will be based on maximum aggregate size:

Aggregate Size	Minimum Lift thickness
A, 4*; B, 3*	40 mm (**1 ½ inch**)
5*	20 mm (**¾ inch**)
C, 2* (for non-wear only)	65 mm (**2 ½ inch**)

*Marshall designation

2360.2 MATERIALS

A Aggregate

A1 General

The aggregate shall consist of sound, durable particles of gravel and sand, crushed stone and sand, or combinations thereof. It shall be free of objectionable matter such as metal, glass, wood, plastic, brick, rubber, and any other material having similar characteristics. Coarse aggregate shall be free from coatings of clay and silt to the satisfaction of the Engineer.

The Contractor shall not compensate for the lack of fines by adding soil materials such as clay, loam, or silt. Overburden shall not be blended into the asphalt aggregate.

Each different material (source, class, kind, or size) shall be fed at a uniform rate from its storage unit. An individual source, class, type, or size of material shall not be stockpile blended with another source, class, type or size of material.

A2 Classification

The aggregate shall conform to one of the following classifications. The class of aggregate to be used shall be the Contractor's option unless otherwise specified in the Contract.

A2a Class A

Class A aggregate shall consist of crushed igneous bedrock (specifically; basalt, gabbro, granite, rhyolite, diorite and andosite) and rock from the Sioux Quartzite Formation. Other igneous or metamorphic rock may be used with specific approval of the Engineer. Class A materials may contain no more than 4.0% non-Class A aggregate. This recognizes the fact that some quarries may contain small pockets of non-Class A material within that source. Intentional blending or addition of non-Class A material is strictly prohibited!

A2b Class B

Class B aggregate shall consist of crushed rock from all other bedrock sources such as carbonate and metamorphic rocks. (gneiss or schist)

A2c Class C

Class C aggregate shall consist of natural or partly crushed natural gravel obtained from a natural gravel deposit.

A2d Class D

Class D aggregate shall consist of 100 percent crushed natural gravel. The crushed gravel shall be produced from material retained on a square mesh sieve having an opening at least twice as large as the Specification permits for the maximum size of the aggregate in the composite asphalt mixture. The amount of carryover (material finer than) the selected screen shall not exceed ten percent.

A2e Class E

Class E aggregate shall consist of a mixture of any two or more of the above classes of approved aggregate (A, B, and D). The use of Class E aggregate, as well as the relative proportions of the different constituent aggregates, shall be subject to the approval of the Engineer. The relative proportions of the constituent aggregates shall be accurately controlled either by the use of a blending belt approved by the Engineer prior to production or by separately weighing each aggregate during batching operations.

A2f Steel Slag

Steel slag may not exceed 25 percent of the mass of the total aggregate. Stockpiles will be accepted for use if the total expansion, determined by ASTM D4792, is less than 0.50%.

A2g Taconite Tailings (TT)

Taconite tailings shall be obtained from ore that is mined westerly of a north-south line located east of Biwabik, Mn (R15W-R16W); except that taconite tailings from ore mined in southwestern Wisconsin will also be permitted for use.

Approved taconite tailing sources are on file with the Department Bituminous Engineer.

A2h Scrap Asphalt Shingles

Scrap asphalt shingles may be included in both wear and non-wear courses to a maximum of 5 percent of the total weight of mixture. Only scrap asphalt shingles from manufacturing waste are suitable. The percentage of scrap shingles used will be considered part of the maximum allowable RAP percentage. Refer to Section 2360.2 G1 to select a virgin asphalt binder grade (use requirements for > 20% RAP, regardless of total RAP/shingle percentage). Scrap Shingle Specifications are on file in the Bituminous Office.

A2i Crushed Concrete and Salvaged Aggregate

Crushed concrete is allowed as an aggregate source for up to 50 percent of the aggregate in non-wear mixtures. Crushed concrete is not allowed in wearing courses.

Salvaged aggregate is allowed as an aggregate source for up to 100 percent of the aggregate in wear and non-wear mixtures. All salvaged aggregate shall be stockpiled uniformly to limit variation in mixture properties. Salvaged aggregates shall meet quality and crushing requirements as specified herein.

A2j Sewage Sludge Ash (SSA)

Sewage sludge ash is allowed as an aggregate source in both wear and non-wear courses to a maximum of 5 percent of the total weight of mixture. Only SSA that meets the Tier II hazard evaluation criteria as approved by Mn/DOT's Office of Environmental Services, Environmental Analysis Section, will be allowed for use in the mixture.

Approved waste incinerator ash sources are on file with the Department Bituminous Engineer.

A3 Recycled Asphaltic Pavement Materials (RAP)

The combined RAP and virgin aggregate shall meet the composite fine aggregate angularity or calculated crushed requirements (both coarse and fine aggregate) for the mixture being produced (calculated crushed allowed for Marshall design only). RAP containing any objectionable material, i.e., road tar, metal, glass, wood, plastic, brick, fabric, or any other objectionable material having similar characteristics will not be permitted for use in the asphalt pavement mixture.

Asphalt binder content in the RAP shall be determined according to Mn/DOT Lab Manual Method 1851 or 1852.

B Manufactured Crushed Fines (-4 material)

All Class A, B, D, and E material that passes the 4.75 mm (**#4**) screen will be considered as crushed fines.

Manufactured Crushed Fines (-4 material) from Class C Aggregate. Produce manufactured crushed fines (-4 material) from a gravel source by passing the gravel over a selected screen, 9.5 mm (**3/8 inch**) or larger, prior to mechanical crushing. The material which passes the 9.5 mm (**3/8 inch**) screen shall not be incorporated into the manufactured crushed fines but may be used as it qualifies for natural sand. The amount of carryover (material finer than) the selected screen shall not exceed ten percent.

The material retained on the 9.5 mm (**3/8 inch**) screen shall be crushed. The material that passes the 4.75 mm (**#4**) screen, after crushing, will be considered as 100% crushed fines. Material retained on the 4.75 mm (**#4**) screen after crushing will not be counted as +4 crushing until tested.

C Quality Requirements

C1 Los Angeles Rattler Test.....AASHTO T96

The Los Angeles Rattler loss on the coarse aggregate fraction

(material retained on the 4.75 mm (**#4**) sieve shall not exceed 40 percent for any individual source used within the mix. An aggregate proportion which passes the 4.75 mm (**#4**) sieve and exceeds 40 percent LAR loss on the coarse aggregate fraction is prohibited from use in the mixture.

C2 Soundness (Magnesium Sulfate).....AASHTO T104

The magnesium sulfate soundness loss at 5 cycles on the coarse aggregate fraction (material retained on the 4.75 mm (**#4**)) shall not exceed the following for any individual source used within the mix: *****

a) No more than 14 % loss on the 19 mm (**¾ inch**) to 12.5 mm (**½ inch**) and larger fractions.
b) No more than 18% loss on the 12.5 mm (**½ inch**) to 9.5 mm (**3/8 inch**) fraction.
c) No more than 23% loss on the 9.5 mm (**3/8 inch**) to 4.75 mm (**#4**) fraction.
d) No more than 18% for the composite loss. (Applies only if all three size fractions are tested).
   * 1) If the composite requirement is met but one or more individual components do not, the source may be accepted if no individual component is more than 110% of the requirement for that component.
   2) If each individual component requirement is met but the composite does not, the source may be accepted if the composite is no greater than 110% of the requirement.

An aggregate proportion which passes the 4.75 mm (**#4**) sieve and exceeds the requirements listed above on the coarse aggregate fraction is prohibited from use in the mixture.

C3 Spall Materials and Lumps..... Mn/DOT Laboratory Manual

Spall is defined as shale, iron oxide, unsound cherts, pyrite, highly weathered and/or soft phyllite and argillite (may be scratched with a brass pencil), and other materials having similar characteristics.

Lumps are defined as loosely bonded aggregations and clayey masses. If the percent of lumps measured in the stockpile or cold feed exceed the values listed below, asphalt production shall cease and compliance shall be determined by dry batching. This procedure may be repeated at any time at the discretion of the Engineer.

Maximum limits for Spall and lumps, expressed as percentages by mass, are listed in Table 2360.3-B2a.

C4 Insoluble Residue Test.....Mn/DOT Laboratory Manual

If Class B carbonate material is used in the mix, the minus 0.075 mm (**#200**) sieve size portion of the insoluble residue shall not exceed 10 percent.

D Aggregate Restrictions

Class B carbonate aggregate restrictions are specified in Table 2360.3-B2a.

E Gradation Requirement

The coarse and fine aggregate shall be combined in such proportions to produce an asphalt mixture meeting all of the requirements defined in this specification and shall conform to the gradation as defined in Table 2360.2-E. Gradation testing shall be conducted in accordance with AASHTO T-11 (-0.075 mm (**-#200**) wash) and T-27.

TABLE 2360.2-E
AGGREGATE GRADATION BROAD BANDS
(% passing of total washed gradation)

Sieve Size (mm (**inch**))	A or 4*	B or 3*	C or 2*	5*	E (SMA)
25.0(**1"**)			100		See SMA Provisions
19.0(**¾"**)		100[1]	85-100		
12.5(**½"**)	100[1]	85-100	45-90		
9.5(**3/8"**)	85-100	35-90	-	100	
4.75 (**#4**)	25-90	20-80	20-75	65-95	
2.36 (**#8**)	20-70	15-65	15-60	45-80	
0.075 (**#200**)	2.0-7.0	2.0-7.0	2.0-7.0	2.0-7.0	

*Marshall Designation

[1]With the approval of the Engineer, the gradation broadband for the maximum aggregate size may be reduced to 97% passing for mixtures containing RAP, when the oversize material is suspected to come from the RAP source. The virgin material must remain 100% passing the maximum aggregate sieve size.

F Additives

An additive is any material added to an asphalt mixture or material, such as mineral filler, hydrated lime, asphalt additives, anti-strip, and similar products that do not have a specific pay item. When a Contract requires additives, compensation is included with the pay items for the appropriate mixture. If the Engineer directs the Contractor to incorporate additives, the compensation will be as Extra Work, at the unit price specified in the proposal. The Department will not compensate the Contractor for additives incorporated at the Contractor's option.

Additives will not be incorporated into the mixture without approval of the Department Bituminous Engineer. Anti-foaming agents shall be added to asphalt cement at the manufacturer's recommended dosage rate. Mineral filler and hydrated lime may be added in a quantity not to exceed 5 percent and 2 percent, respectively, of the total mass of the aggregate. The combination of mineral filler and hydrated lime shall not exceed 5 percent of the total mass of aggregate. The Engineer will approve or disapprove methods for addition of additives.

F1 Mineral Filler..... 3145

F2 Hydrated Lime..... 3145

Hydrated lime used in asphalt mixtures shall meet the requirements of ASTM C977 and have a maximum of eight percent unhydrated oxides (as received basis). The method of introducing and mixing the hydrated lime and aggregate shall be subject to approval by the Engineer prior to beginning mixture production.

F3 Liquid Anti-Stripping Additive

When a liquid anti-strip additive is added to the asphalt binder, blending shall be completed before the asphalt binder is mixed with the aggregate. Liquid anti-strip additives that alter the asphalt binder, such that it fails to meet the Performance Grade (PG) requirements, shall not be used. Liquid anti-strip may be added by the supplier at the refinery or by the Contractor at the plant site. The company/supplier adding the additive shall be responsible for testing the binder/additive blend to ensure compliance with the AASHTO M 320, Standard Specification for Performance Graded Asphalt Binder. No paving will be allowed until the asphalt binder/additive blend has been tested and results show that binder/additive blend properties meet the criteria in Section 2360.2G. The testing shall be done in accordance with a Mn/DOT approved Asphalt Binder QC Plan. Requirements for the Asphalt Binder QC Plan are on file in the Bituminous Office.

The following requirements for HMA mixture and asphalt binder must also be met when liquid anti-strip is added at the HMA plant site.

Mixture Requirements at Design:

1) The Contractor must design the mixture with the same asphalt binder that will be supplied to the plant site. (Both Laboratory Mixture Design (Option 1) and Modified Mixture Design (Option 2).
2) The Contractor must provide documentation with either design option that includes Tensile Strength Ratio results with the liquid anti-strip dosed at the optimal rate. Documentation must include verification the binder/additive

blend meets AASHTO M 320 at the optimal dose rate.

Contractor Production Testing Requirements for Asphalt Binder/Liquid Anti-Strip Blend:

1) The Contractor shall, on a daily basis, sample and test the asphalt binder/anti-strip blend. Testing of the blend can be by viscosity, penetration, or dynamic shear rheometer (DSR). When a polymer modified asphalt binder is specified, the Contractor shall use the DSR as the daily QC test.
2) The Contractor shall, on a weekly basis, send the Engineer and Mn/DOT Chemical Laboratory Director a weekly QC report summarizing the results of the daily testing as required in number 1.
3) The Contractor shall, on a bi-weekly basis, test the binder/anti-strip blend to ensure compliance with the AASHTO M 320, Standard Specification for Performance Graded Asphalt Binder (minimum 1/project). Test results shall be sent to the Engineer and Mn/DOT Chemical Laboratory Director.
4) In addition to the sampling requirements listed above, the Contractor shall obtain asphalt binder/anti-strip blend field verification samples according to 2360.4 E12.

Liquid Anti-Strip Additive Metering System:

1) The metering system shall include a liquid anti-strip flow meter in addition to an anti-strip pump. The flow meter shall be connected to the liquid anti-strip supply to measure and display only the anti-strip being fed to the asphalt binder.
2) The meter readout shall be positioned for convenient observation.
3) There shall be a means provided for comparing the flow meter readout with the calculated output of the anti-strip pump. See number 7.
4) The system shall display in units of liters (**gallons**) to the nearest liter (**gallon**) or in units of metric tons (**tons**) to the nearest 0.001 metric tons (**0.001 tons**), the accumulated anti-strip quantity being delivered to the mixer unit.
5) The system shall be calibrated and adjusted to maintain an accuracy of $\pm$ one percent error.
6) Calibration shall be required for each plant set-up prior to production of mixture.
7) The Engineer may require, on a daily basis, the Contractor "stick" the anti-strip tank at the end of the days production to verify anti-strip usage quantities.
8) The system shall provide for a convenient method for sampling the binder/anti-strip after blending has occurred.

9) Alternative blending and metering systems must be pre-approved by the Engineer.

F4 Coating and Anti-Stripping Additive.....3161

G Asphalt Binder Material .....AASHTO M 320

Asphalt binder material shall meet the requirements of PG asphalt binder testing tolerances, sampling rates, testing procedures, and acceptance criteria based on the most current Mn/DOT Technical Memorandum, titled "Inspection, Sampling, and Acceptance of Bituminous Materials." The PG asphalt binder cannot be modified with air blowing procedures unless the Department Bituminous Engineer approves it. The Contractor shall not use petroleum distillates such as fuel oil, diesel fuel or other fuels in the asphalt tanks. A statement shall be provided by the supplier for recommended laboratory mixing and compaction temperatures and field maximum mixing and compaction temperatures.

G1 Asphalt Binder Selection Criteria for All Mixtures with RAP

Overlay	**Specified PG Asphalt Binder Grade**	**Virgin Asphalt Binder Grade to be used with RAP**	
		≤ 20% RAP	**> 20% RAP**
	64-22	64-22	64-28
	Other PG Grades	No grade adjustment	No grade adjustment
New Construction (1)	**Specified PG Asphalt Binder Grade**	**Virgin Asphalt Binder Grade to be used with RAP**	
		≤ 20% RAP	**> 20% RAP**
	52-34	52-34	Not allowed *
	58-28	58-28	58-28
	58-34	58-34	Not allowed *
	64-28	64-28	64-28
	64-34	64-34	Not allowed *
	Other PG Grades	No grade adjustment	Not allowed *

* When approved by the Engineer, the virgin asphalt binder grade can be selected by using the blending chart procedure on file in the Bituminous Office. Mn/DOT may take production samples for information/verification of compliance with a specified asphalt binder grade.

(1) Includes cold inplace recycle, reclaiming, and reconstruction.

2360.3 MIXTURE DESIGN

A Mixture Design General

The asphalt mix may be designed using one of the following two Contractor trial mix design options. Review of mixture designs will be performed in the District Materials Laboratory lab where the Project is located. The addition of aggregates and materials not included in the original mixture submittal is prohibited.

It is the Contractor's responsibility to design a Marshall mixture in accordance with the most current AASHTO T-245, the Asphalt Institute's Mix Design Methods for Asphalt Concrete MS-2, and the Mn/DOT Laboratory Manual such that it meets the requirements of this specification.

For Marshall design, the design air void content of the mixture is dependent on the mixture type, regardless of the location in the pavement structure. Design air void content for LV and MV mixtures is 3.0% and 3.5%, respectively.

It is the Contractor's responsibility to design a gyratory mixture in accordance with the most current AASHTO T-312, the Asphalt Institute's Superpave Mix Design Manual SP-2 (2-hour short term aging period is used for volumetric), and the Mn/DOT Laboratory Manual such that it meets the requirements of this specification.

For gyratory design, the design air void content of the mixture at design shall be 4.0% at the design number of gyrations (N_{design}) for mixtures placed in the upper 100 mm (**4 inches**) of the finished surface. The design air void content of the mixture at design shall be 3.0% at the design number of gyrations (N_{design}) for mixtures placed at depths more than 100 mm (**4 inches**) from the surface and on all (wear and nonwear) shoulders that do not carry traffic. If less than 25% of a layer is within 100 mm (**4 inches**) of the surface, the layer may be considered to be below 100 mm (**4 inches**) for mix design purposes (non-wear).

Design Air Void Requirement for Gyratory Mixtures

	SP Wear	**SP Non-wear**	**SP Shoulder****
Location from surface	≤ 100 mm (**4 inch**)*	> 100 mm (**4 inch**)*	All Wear and Non-Wear
Air Voids	4.0%	3.0%	3.0%

* If less than 25% of a layer is within 100 mm (**4 inches**) of the surface, the layer may be considered to be below 100 mm (**4 inches**) for mix design purposes.

** Shoulders that do not carry traffic.

B Laboratory Mixture Design (Option 1)

Test results and documentation as described in Section 2360.3C shall be submitted with the materials described below for

consideration by the Department Bituminous Engineer or District Materials Engineer to verify compliance with these specifications and to issue a Mixture Design Report.

B1 Aggregate Sample

At least 15 working days prior to the start of asphalt production, the Contractor shall submit to the Department Bituminous Engineer or the District Materials Engineer a 35 kg (**80 pound**) sample of representative aggregate retained on the 4.75 mm sieve (**#4**) and a 15 kg (**35 pound**) sample of material passing the 4.75 mm sieve (**#4**) for quality testing. The Contractor shall provide 24 hour notice of intent to sample aggregates. These samples will be tested for quality of each source, class, type, and size of virgin and non-asphaltic salvage aggregate source used in the mix design. The Contractor shall retain a companion sample of equal size until a Mixture Design Report is issued. Quality requirements are defined in Section 2360.2C.

Aggregates that require the magnesium sulfate soundness test shall be submitted to the Department Bituminous Engineer or District Materials Engineer at least 30 calendar days prior to the start of asphalt production. Dispute resolution procedures for aggregate qualities are on file in the Bituminous Office.

B2 Mixture Sample

At least 7 working days prior to the start of asphalt production, the Contractor shall submit in writing a proposed Job Mix Formula (JMF) for each combination of aggregates to the Department Bituminous Engineer or District Materials Engineer for review. A Level II Quality Management mix designer must sign the proposed JMF. For each JMF submitted, the Contractor shall include test data to demonstrate conformance to mixture properties as specified in Table's 2360.3-B2b and 2360.3-B2c. The proposed JMF shall be submitted on forms approved by the Department. In addition, the Contractor shall submit an uncompacted mixture sample plus briquettes compacted at the optimum asphalt content and required compactive effort conforming to the JMF for laboratory examination and evaluation. Mixture sample size and number of compacted briquettes are as follows:

TABLE 2360.3-B2
MIXTURE SAMPLE REQUIREMENTS

Item	**Gyratory Design**	**Marshall Design**
Un-compacted Mixture Sample Size	30 kg (**75 pounds**)	18 kg (**40 pounds**)
Number of compacted briquettes	2	3

B2a Mixture Aggregate Requirements

The aggregate fractions shall be sized, graded, and combined in such proportions that the resulting mixture will meet the requirements listed in Section 2360.2-E and Table 2360.3-B2a shown below.

TABLE 2360.3-B2A
MIXTURE AGGREGATE REQUIREMENTS

Aggregate Blend Property	Traffic Level 2& LV	Traffic Level 3 & MV	Traffic Level 4	Traffic Level 5	SMA T. Level 6
20 year Design ESAL's	<1 million	1 - 3 million	3 - 10 million	10 – 30 million	See SMA Prov.
Coarse Aggregate Angularity (ASTM D5821) (one face / two face), %-Wear (one face / two face), %-NonWear	 30/- 30/-	 55 / - 55 / -	 85 / 80 60/ -	 95 / 90 80 / 75	-
Fine Aggregate Angularity (FAA) (AASHTO T304, Method A) %- Wear %-Non-Wear	 40(2) 40(2)	 42(1) 40(1)	 44 40	 45 40	-
Flat and Elongated Particles, max(2) % by weight, (ASTM D 4791)	-	10 (3:1 ratio)	10 (3:1 ratio)	10 (3:1 ratio)	-
Clay Content(2) (AASHTO T 176)	-	-	45	45	-
Total Spall in fraction retained on the 4.75mm (**#4**) sieve	5.0	2.5	1.0	1.0	-
Maximum Spall Content in Total Sample	5.0	5.0	1.0	1.0	-
Maximum Percent Lumps in fraction retained on the 4.75mm (**#4**) sieve	0.5	0.5	0.5	0.5	-
Class B Carbonate Restrictions					
Maximum% -4.75mm (**-#4**) Final Lift/All other Lifts	100/100	100/100	80/80	50/80	-
Maximum% +4.75mm (**+#4**) Final Lift/All other Lifts	100/100	100/100	50/100	0/100	-
Gyratory Max. allowable RAP percentage Wear / Non Wear	30/40	30/30	30/30	30/30	
Marshall Max. allowable RAP percentage Wear / Non Wear	30/40	30/30			

(1) For Marshall design, the Contractor may determine –4 crushing

by either FAA of uncompacted voids or calculation of crush from the composite blend. The choice must be made prior to start of production. Manufactured crushed fines requirement is 25%. RAP sand will be considered 50% crushed if the angularity index equals or exceeds 40, and 100% crushed if the angularity index equals or exceeds 45.

(2) Not applicable under Marshall design.

B2b Mixture Requirements

Mixture evaluation will be based on the trial mix tests and the corresponding requirements listed in Table 2360.3-B2b and Table 2360.3-B2c.

B2c VMA Criteria

The voids in mineral aggregate (VMA) of the mixture at design and during production shall meet the minimum criteria as shown in Table 2360.3-B2c at the specified compaction level. VMA shall be calculated according to the procedures outlined in Asphalt Institutes SP-2 or MS-2 manual. VMA is a design and acceptance/process control requirement.

B3 Tensile Strength Ratio Sample

Mixture or briquettes that represent the mixture at optimum asphalt content, shall be submitted at least 7 days prior to actual production for verification of moisture sensitivity retained tensile strength ratio (TSR). Material submitted for TSR verification may be tested for maximum specific gravity G_{mm} compliance in addition to TSR results. Failure to meet the G_{mm} tolerance will result in rejection of the submitted mix design. A new mix design submittal will be required and will be subject to provisions described in Section 2360.3C. One of the following options may be used to verify that the tensile strength ratio (TSR) meets the requirements in Table 2360.3-B2b.

Option A) The Contractor will batch material at the design proportions including optimum asphalt. Immediately (before curing) split the sample and allow samples to cool to room temperature. Submit 35 kg (**77 pounds**) of mixture to the District Materials Laboratory for curing and test verification. Both groups will use a two (2) hour cure time (± 15 minutes) at 144^{o}C (**290^{o}F**) and follow procedures in ASTM D 4867-92, Mn/DOT modified as defined in the Mn/DOT Laboratory Manual.

Option B) The Contractor batches, cures (as indicated in option A), compacts, and submits briquettes and uncompacted mixture as specified below.

TABLE 2360.3-B2B
MIXTURE REQUIREMENTS

	Traffic Level 2	Traffic Level 3	Traffic Level 4	Traffic Level 5	SMA T. Level 6
20 year Design ESAL's	< 1 million	1 - 3 million	3 - 10 million	10 – 30 million	See SMA Prov.
Gyratory Mixture Requirements					
Gyrations for $N_{initial}$	6	7	8	8	-
Gyrations for N_{design}	40	60	90	100	-
Gyrations for $N_{maximum}$	60	90	140	160	-
Air Voids, % -- Wear Air Voids, % -- Non-Wear & All Shoulder	4.0 3.0	4.0 3.0	4.0 3.0	4.0 3.0	-
% G_{mm} at $N_{initial}$ – Wear % G_{mm} at $N_{initial}$ – Non-Wear & All Shoulder	- -	≤ 91.5 ≤ 92.5	≤ 90.5 ≤ 91.5	≤ 90.0 ≤ 91.0	
% G_{mm} at $N_{maximum}$ – Wear % G_{mm} at $N_{maximum}$– NonWear & All Shoulder	≤ 98.0 ≤ 99.0	≤ 98.0 ≤ 99.0	≤ 98.0 ≤ 99.0	≤ 98.0 ≤ 99.0	- -
Tensile Strength Ratio [(1)], min%	75[(2)]	75[(2)]	80[(3)]	80[(3)]	-
Fines/Effective Asphalt	0.6 – 1.2	0.6 – 1.2	0.6 – 1.2	0.6 – 1.2	-
VFA, % -- Wear NonWear	65 - 78 70 – 83	65 - 78 70 - 83	65 - 76 70 - 82	65 - 76 70 - 82	
Marshall Mixture Requirements	LV	MV			
Marshall Blows	50	50	-	-	-
Air Voids, %	3.0	3.5	-	-	-
Tensile Strength Ratio [(1)], min%	70[(4)]	70[(4)]			
Stability, minimum N **(lb f)**	5000 (**1125**)	6000 (**1350**)			
Fines/Effective Asphalt Wear Non-Wear	0.6 - 1.30 0.6-1.40	0.6 - 1.30 0.6-1.40	-	-	-

(1) See Section 2360.4 E9. Use 150 mm (**6 inch**) specimens for gyratory and 100 mm (**4 inch**) specimens for Marshall design.
(2) Mn/DOT Min = 65, [(3)] Mn/DOT Min = 70, [(4)] Mn/DOT Min = 60

TABLE 2360.3-B2C
VOIDS IN MINERAL AGGREGATE (VMA) MIXTURE REQUIREMENTS

Gradation	Fine Mixture % Pass 2.36 mm (**#8**)	VMA Minimum	Coarse Mixture % Pass 2.36 mm (**#8**)	VMA Minimum
A or 4*	> 47	15.0**	≤ 47	14.5*
B or 3*	> 39	14.0	≤ 39	13.5
C or 2*	> 35	13.0	≤ 35	12.5
5*	-----	15.0**	-----	-----
E	See SMA Provisions			

*Marshall designation.
**For LV 4 and LV 5 mixes lower VMA requirements by 0.5%

TABLE 2360.3-B3
OPTION B MIXTURE REQUIREMENTS

Item	**Gyratory Design**	**Marshall Design**
Un-compacted Mixture Sample Size	8,200 g	8,200 g
Number of compacted briquettes(1)	6	9
Compacted briquette air void content	6.5 – 7.5%	6.0 – 8.0%

(1) 150mm (**6 inch**) specimens for gyratory design
100mm (**4 inch**) specimens for Marshall design

B4 Aggregate Specific Gravity..... ..... AASHTO T84 and T85, Mn/DOT Modified

The Contractor shall determine the specific gravity of all aggregate used in the mixture.

C Documentation

Each proposed JMF submitted for review under Section 2360.3B and 2360.3D shall include the following documentation and test results.

(1) The name(s) of the individual(s) responsible for the Quality Control of the mixture during production.
(2) The low projects number on which the mixture will be used.
(3) The percentage in units of 1 percent (except the 0.075 mm sieve (**#200**) in units of 0.1 percent) of aggregate passing each of the specified sieves for each aggregate to be incorporated into the mixture. The gradation of aggregate

from salvaged asphaltic material shall be derived from the material after the residual asphalt has been extracted.

(4) The source and description of the materials to be used. The aggregate pit or quarry source number. The proportion of each material (in percent of total aggregate).

(5) The composite gradation based on (3) and (4) above. Note: Include virgin composite gradation based on (4) and (5) above for mixtures containing RAP.

(6) The bulk (dry) and apparent specific gravities and water absorption (by % weight of dry aggregate) of both coarse and fine aggregate, for each product used in the mixture (including RAP). Use AASHTO T-84 and T-85 Mn/DOT modified as defined in the Mn/DOT Laboratory Manual. The tolerance allowed between the Contractor's and the Department's specific gravities are G_{sb} (individual) = 0.040 (+4 AND -4) and G_{sb} (combined) = 0.020.

(7) The composite gradation plotted on a FHWA 0.45 power chart. (Federal form PR-1115)

(8) For mixtures containing RAP include extracted asphalt binder content of the RAP with no retention factor included.

(9) The percentage (in units of 0.1 percent) and PG grade of asphalt binder material to be added, based upon the total mass of the mixture.

(10) When using laboratory mixture design Option 1 (2360.3B) or Option 2 (2360.3D), include the following:

(a) A minimum of three different asphalt binder contents (minimum 0.4 percent between each point), with at least one point at, one above and one below the optimum asphalt binder percentage.

(b) The maximum specific gravity at each asphalt binder content. The theoretical maximum specific gravity used for percent air voids determination shall be calculated based on the average of the effective specific gravities measured by a minimum of two maximum specific gravity tests at the asphalt contents above and below the expected optimum asphalt binder content.

(c) The test results for the individual and average bulk specific gravity, density, and heights, of at least two specimens at each asphalt binder content. For Marshall design include the test results for the individual and average bulk specific gravity, density, height, stability, and flow of at least three specimens at each asphalt binder content.

(d) The percent air voids in the mixture at each asphalt

binder content.

(e) The percent Voids in Mineral Aggregate (VMA) at each asphalt binder content.

(f) The fines to Effective Asphalt (F/A) ratio calculated to the nearest 0.1 percent.

(g) TSR results at the optimum asphalt binder content.

(h) Graphs showing air voids, voids in the mineral aggregate, Gmb, Gmm and unit weight vs. percent asphalt binder content for each of the three asphalt binder contents submitted with trial mix.

(11) Optional Add-Rock/Add-Sand Provisions

If the Contractor chooses to use the add-material option to augment the submitted JMF, the Contractor shall provide samples of the aggregate for quality analysis in accordance with Section 2360.3B1. The Contractor shall provide mix design data for two additional design points per add-material. One point shall show a proportional adjustment to the submitted JMF that includes 5 percent, by mass, add-material at the JMF optimum asphalt percent. The second point shall show a proportional adjustment to the submitted JMF that includes 10 percent, by mass, add-material at the JMF optimum asphalt percent. The following information will be reported for each of these two points:

(a) The maximum specific gravity (average of two tests).

(b) The test results for the individual and average bulk specific gravity, density, and height of at least two specimens at the optimum asphalt binder content. For Marshall design include the test results for the individual and average bulk specific gravity, density, height, stability, and flow of at least three specimens at the optimum asphalt binder content.

(c) The percent air voids in the mixture for each point.

(d) The Fines to Effective Asphalt ratio calculated to the nearest 0.1 of a percent.

(e) Coarse and Fine Aggregate crushing counts

Up to two add-materials will be allowed per mix design submittal. Aggregate quality and mix characteristics are required for each proposed add-material and shall be submitted at the time of the original trial mix submittal. No mixture sample or briquettes are required for these two additional points.

Additional Documentation for:

Gyratory Design

(G1) The test results from the composite aggregate blend at the proposed JMF proportions indicating compliance with Coarse Aggregate Angularity and Fine Aggregate Angularity as shown in Table 2360.3-B2a.

(G2) The design traffic level and the initial, design, and maximum number of gyrations $N_{initial}$, N_{design}, and $N_{maximum}$.

(G3) The temperature ranges the mixture is intended to be discharged from the plant and compacted at the roadway shall be provided by the asphalt binder supplier. Temperatures to be included are, laboratory mixing and compaction temperature ranges and maximum field mixing and compaction temperatures.

(G4) Evidence that the completed mixture will conform to all specified physical requirements as follows:

Design air Voids (V_a), VMA, VFA, TSR, F/A_e (Fines to effective asphalt ratio), Densification $\%G_{mm}$ at $N_{initial}$, N_{design}, and $N_{Maximum}$.

(G5) Labeled gyratory densification tables and curves, generated from the gyratory compactor, for all points used in the mixture submittal.

Marshall Design

(M1) The test results from the composite aggregate blend at the proposed JMF proportions indicating compliance with fine aggregate angularity uncompacted voids as shown in Table 2360.3-B2a. Or calculated -4.75 mm (-**#4**) crushing from the composite blend of the proposed JMF. Selection of either FAA or -4.75 mm (-**#4**) crushing shall be made at the time of mix design submittal. This selection will dictate the choice of method used for determination of compliance and acceptance for the duration of time the Mixture Design Report is in force. RAP sand will be considered 50% crushed if the angularity index equals or exceeds 40, and 100% crushed if the angularity index equals or exceeds 45.

D Modified Mixture Design (Option 2)

Test results and documentation as described in Section 2360.3C shall be submitted to the Department Bituminous Engineer or the District Materials Engineer to verify compliance with mix design requirements and issue a Mix Design Report. Mixture submittal is not required. The Contractor may use this option if **all** of the following conditions are met:

a) The aggregates in the proposed Mix Design Report have been used, in part, in other Mix Design Reports. Additionally, the

aggregates must have been previously tested for and meet all applicable quality requirements in the current construction season.

b) The Level II mix designer submitting the mixture design must have a minimum of 2 years experience in mixture design.

c) The Contractor and his representatives cannot have violated the requirements of 1512 Unacceptable and Unauthorized Work relating to mixture design or mixture production within the last 12 month period.

D1 JMF Submittal

At least 2 working days prior to the start of asphalt production, the Contractor shall submit in writing a proposed Job Mix Formula (JMF) for each combination of aggregates to the Department Bituminous Engineer or District Materials Engineer for review. A Level II Quality Management mix designer must sign this proposed JMF. For each JMF submitted, the Contractor shall include documentation as outlined in Section 2360.3C to demonstrate conformance to mixture properties as specified in Table 2360.3-B2b and 2360.3-B2c. The proposed JMF shall be submitted on forms approved by the Department.

D2 Initial Production Test Verification

At the start of production, the testing frequency for the first 1,800 metric tons (**2,000 tons**) of each mix type shall be as specified in Table 2360.4-D.

All mixture placed on Mn/DOT projects shall meet the specified quality indicators and required field density. Failure to do so will result in reduced payment or removal and replacement with acceptable material.

The Department shall take a mix verification sample within the first four samples at the start of production of each mix type.

D3 Tensile Strength Ratio Sample

See Section 2360.4E9.

D4 Marshall Stability (Marshall Design Only)

On the first day of production, for each different mix design, at the same time the verification sample is obtained, an additional sample shall be obtained for Department evaluation of Marshall stability. This sample may be tested at the discretion of the District Materials Engineer. The Contractor is not required to test stability on production mixture.

If the Marshall stability fails to meet the minimum requirements as listed in Table 2360.3-B2c the Contractor shall stop production immediately. The Contractor will be required to submit a revised mix design, with bituminous mixture at optimum asphalt content, to

the District Materials Laboratory. If the mixture meets the minimum stability requirement production may be resumed. If the stability fails the second time, the Mix Design Report will be revoked. The Contractor will then be required to submit a new mix design according to Laboratory Mixture Design 2360.3B, Option 1. A new Mix Design Report will be issued upon successful verification of the new mixture design submittal.

E Mixture Design Report

A Mixture Design Report consists of the JMF (Job Mix Formula). The JMF includes composite gradation, aggregate component proportions, asphalt binder content of the mixture, design air voids, Voids in Mineral Aggregate, and aggregate bulk specific gravity values. JMF limits will be shown for gradation control sieves, percent asphalt binder content, air voids, and VMA. Issuance of a Mixture Design Report confirms the mixture has been reviewed for and meets volumetric properties only. No guaranty or warranty, either expressed or implied, is made regarding placement and compaction of the mixture.

A Department reviewed Mixture Design Report is required for all paving except for small quantities of material provided under Section 2360.5H. All submitted materials must meet aggregate and mixture design requirements before a Mixture Design Report is issued. The Department will review two trial mix designs per mix type designated in the plan, per Contract at no cost to the Contractor. Additional mix designs will be verified at a cost of $2000 per design, payable to the Commissioner of Transportation.

For city, county, and other agency projects, the Contractor shall provide to the District Materials Laboratory a complete Project proposal including addenda, supplemental agreements, change orders, and any Plan sheets (including typical sections) that affect the mix design. The Department will not start the verification process without this information.

2360.4 MIXTURE QUALITY MANAGEMENT (Quality Control/Quality Assurance)

A Quality Control (QC)

The Contractor shall provide and maintain a quality control program for HMA production. A quality control program is defined as all activities, including mix design, process control inspection, sampling and testing, and necessary adjustments in the process that are related to the production of a hot mix asphalt (HMA) pavement which meets the requirements of the specifications.

A1 Contractor Certified Plant HMA

A1a Certification Procedure

The Contractor shall:

(1) Complete application form and request for plant inspection.
(2) Provide a site map of stockpile locations.
(3) Pass plant and testing facility inspection by having the Plant Inspector and Bituminous Plant Authorized Agent complete and sign the Asphalt Plant Inspection Report (TP 02142-02, TP 02143-02). By signing the Asphalt Plant Inspection Report, the HMA plant authorized agent agrees to calibrate and maintain all plant and laboratory equipment within allowable tolerances set forth in these specifications, Standard Specifications for Construction, and the Mn/DOT Bituminous Manual.
(4) Obtain a Mixture Design Report prior to production.

A1b Maintaining Certification

To maintain certification, the plant must produce, test, and document all certified plant asphalt mixtures in accordance with the above requirements on a continuous basis. Continuous basis means all asphalt mixtures supplied from a certified plant to any Department project with 2360 asphalt mixtures must be sampled and tested in accordance with 2360 requirements and the Schedule of Materials Control.

The Contractor shall assure the plant certification procedure is performed annually after winter suspension and before producing material for a Project. In addition, a first-day sampling and testing frequency rate as stated in Table 2360.4-D shall be followed.

The Contractor shall recertify a plant when it is moved to a new location or a previously occupied location.

A1c Revocation of Plant Certification

The Department Construction Engineer may revoke certification of an asphalt plant when requirements are not being met or records are falsified. The Department may revoke the Technician Certification for the individual involved.

The Department Bituminous Engineer and Department Contract Administrator will maintain a list of companies who have had their asphalt plant certification revoked.

B Quality Assurance (QA)

The Department will perform QA testing as part of the acceptance process. The Engineer is responsible for QA testing, records, and acceptance. The Engineer will accomplish the QA process by:

(1) Conducting Quality assurance and verification sampling and testing.
(2) Observing sampling and tests performed by the QC personnel.

(3) Taking additional samples at any time and any location during production.
(4) Monitoring the required QC summary sheets and control charts.
(5) Verifying calibration of laboratory testing equipment.
(6) Communicating Mn/DOT test results to the Contractor's QC personnel in a timely manner.
(7) Ensuring Independent Assurance Sampling and testing requirements are met.

C Contractor's Quality Control

C1 Personnel Requirements

Along with the proposed mix design data, the Contractor shall submit to the Engineer an organizational chart listing the names and phone numbers of individuals and alternates responsible for mix design, process control administration, and inspection. The Contractor shall also post a current organizational chart and if required by the Engineer, post a daily roster of individuals performing QC testing in the Contractor's test facility.

The Contractor's quality control organization or private testing firm shall have Certified Technicians who have met the requirements on file with the Department's Technical Certification program. Individuals performing process control testing must be certified as a Level I Bituminous Quality Management (QM) Tester. Individuals performing mix design calculations or mix design adjustments must be certified as Level II Bituminous QM Mix Designer. The Contractor shall have a Certified Level II Bituminous QM Mix Designer available to make any necessary process adjustments. The Contractor shall have a minimum of one person per paving operation certified as a Level II Bituminous Street Inspector.

C2 Laboratory Requirements

The Contractor shall furnish and maintain a laboratory at the plant site or other site as approved by the Engineer. The laboratory shall be furnished with the necessary equipment and supplies for performing Contractor quality control testing. The laboratory equipment shall meet the requirements listed in Section 400 of the Mn/DOT Bituminous Manual and these specifications, including having extraction capabilities. The laboratory shall be calibrated, and operational prior to the beginning of production. In addition to the requirements listed above, the laboratory shall be equipped with a telephone for use by the Contractor or the Engineer. A fax machine and copy machine shall be available for use by the Contractor or the Engineer at the laboratory site. The laboratory shall also include a computer and printer. The computer shall have the following minimum requirements: 1) Intel based with either Celeron or Pentium

IV processor with a minimum processor speed of 1.8 MHZ. 2) CD writer with CD/RW capability and a minimum write speed of 16x. 3) Windows 2000 or Windows XP with Microsoft Excel version 97 or newer. The printer must be able to print control charts.

The Engineer shall be allowed to inspect measuring and testing devices to confirm both calibration and condition. The Contractor shall calibrate and correlate all testing equipment in accordance with the latest version of the Mn/DOT Bituminous Manual.

D Sampling and Testing

The Contractor shall ensure that all QC samples are taken at random locations. Random number generation and determination of random sample location shall be consistent with the Mn/DOT Bituminous Manual Section 5-693.7 Table A or Section 5 of ASTM D3665. The Engineer may approve alternate methods of random number generation.

The tests for mixture properties shall be conducted on representative portions of the mix, quartered from a larger sample of mixture taken from behind the paver, or when approved by the Engineer, an alternate sampling location. The procedure for truck box sampling, an alternate sampling location, is on file in the Bituminous Office. When an alternate sampling location is approved and used by the Contractor, the daily verification sample must still be taken from behind the paver.

The Contractor shall obtain a sample of at least 25 kg (**55 pounds**). This sample may be either split in the field or transported to the test facility by a method to retain heat to facilitate sample quartering procedures. The Contractor shall store and retain mixture bulk samples and companion samples for the Department for a period of 7 working days. The Contractor shall maintain these split samples in containers labeled with companion numbers. The Contractor shall perform QC sampling and testing according to the following schedule.

Determine the planned tonnage for each mixture to be produced during the production day. Divide the planned production by 1000. Round the number to the next higher whole number. This number will be the number of production tests required for that mixture. Required production tests are listed in Table 2360.4-E. Split the planned production into even increments and select sample locations as described above. If actual tonnage exceeds planned tonnage additional tests may be required. During production, mixture volumetric property tests will not be required when mix production is less than 270 metric tons (**300 tons**). However, production tests will be required when the accumulative tonnage on successive days exceeds 270 metric tons (**300 tons**).

At the start of production, the testing frequency for the first 1800 metric tons (**2,000 tons**) of each mix type shall be as follows:

TABLE 2360.4-D
PRODUCTION START-UP TESTING RATES

Production Test	**Testing Rates**	**Test Reference**	**Section**
Bulk Specific Gravity	1 test per 450 metric tons (**500 tons**)	AASHTO T312, T166 Mn/DOT modified	2360.4E2
Maximum Specific Gravity	1 test per 450 metric tons (**500 tons**)	AASHTO T209 Mn/DOT modified	2360.4E3
Air Voids (calculated)	1 test per 450 metric tons (**500 tons**)	AASHTO T269, T312	2360.4E4
Asphalt Content	1 test per 450 metric tons (**500 tons**)	Bit & Lab Manual	2360.4E1
VMA (Calculated)	1 test per 450 metric tons (**500 tons**)	AI MS 2 & SP 2	2360.4E5
Gradation	1 test per 900 metric tons (**1000 tons**)	AASHTO T11, T27, T30Mn/DOT modified	2360.4E6
Coarse Aggregate Angularity	1 test per 900 metric tons (**1000 tons**)	ASTM D5821	2360.4E7
Fine Aggregate Angularity (FAA)[(1)]	1 test per 900 metric tons (**1000 tons**)	AASHTO T304, Method A	2360.4E8

[(1)] Marshall design allows -4.75mm (**-#4**) manufactured crushed fines calculation per Mn/DOT Bituminous Manual

E Production Tests

When more than one Mn/DOT approved test procedure is available, the Contractor shall select, with the approval of the Engineer, one method at the beginning of the Project and use that method for the entire Project. The Contractor and Engineer may agree to change test procedures during the construction of the Project.

TABLE 2360.4-E
PRODUCTION SAMPLING AND TESTING RATES

Production Test	Sampling/Testing Rates	Test Reference	Section
Bulk Specific Gravity	Divide the planned production by 1000. Round the number to the next higher whole number.	AASHTO T312, T245 T166 Mn/DOT mod	2360.4E2
Maximum Specific Gravity	"	AASHTO T209 Mn/DOT modified	2360.4E3
Air Voids (calculated)	"	AASHTO T269, T312	2360.4E4
Asphalt Content	"	Bit & Lab Manual	2360.4E1
VMA (Calculated)	"	AI MS 2 & SP 2	2360.4E5
Gradation	1 gradation per 1,800 metric tons (**2,000 tons**), or portion thereof (minimum of one per day)	AASHTO T11, T27, T30Mn/DOT modified	2360.4E6
Coarse Aggregate Angularity	2 tests/day for a minimum of 2 days, then 1 per day if CAA is met. If CAA >8% of requirement, 1 sample/day but test 1/week.	ASTM D5821	2360.4E7
Fine Aggregate Angularity (FAA)[1]	2 tests/day for a minimum of 2 days, then 1 per day if FAA is met. If FAA >5% of requirement, 1 sample/day but test 1/week.	AASHTO T304, Method A	2360.4E8
TSR	1st sample at 5,000 tons or by second day of production, then sample at every 18,000 metric tons (**20,000 tons**)	ASTM D4867 Mn/DOT modified	2360.4E9
Aggregate Specific Gravity	1 per 9,000 metric tons (**10,000 tons**)	AASHTO T84 & T85, Mn/DOT modified	2360.4E10
Mixture Moisture Content	Daily unless exempted by Engineer	Mn/DOT 5-693.950	2360.4E11
Asphalt Binder	Sample 1st load (each grade) then 1 per 1,000,000 liter (**250,000 gallon-sample size 1 quart**.)	Mn/DOT 5-693.920	2360.4E12

(1) Marshall design allows -4.75mm (**-#4**) manufactured crushed fines calculation per Mn/DOT Bituminous Manual

E1 Asphalt Binder Content
(a) Spot Check (Virgin only)..... Mn/DOT Bituminous Manual
(b) Incinerator Oven [(1)] ..... Mn/DOT Laboratory Manual Method 1853
(c) Chemical Extraction ..... Mn/DOT Laboratory Manual Method 1851 or 1852
(d) Meter Method (Virgin only) ..... Mn/DOT Bituminous Manual

[(1)] Incinerator Oven may not be used when the percentage of Class B material exceeds 50% within the composite blend, unless a correction factor is determined by the Contractor and approved by the District Materials Engineer.

E2 Marshall Bulk Specific Gravity, G_{mb} (3 specimens)..... AASHTO T166, Mn/DOT Modified, or

E2a Gyratory Bulk Specific Gravity, G_{mb} (2 specimens) ..... AASHTO T312, T166, Mn/DOT Modified

E3 Maximum Specific Gravity, G_{mm} ..... AASHTO T209, Mn/DOT Modified

E4 Air Voids - Individual and Isolated (calculation) ..... AASHTO T269, T312

Isolated air voids are calculated using the maximum mixture specific gravity and the corresponding bulk specific gravity from a single test. Individual air voids are calculated from the maximum specific gravity moving average and the bulk specific gravity from that single test.

For gyratory design, compaction shall be conducted to $N_{maximum}$ and calculations for $\%G_{mm}$ at $N_{initial}$ and N_{design} shall be determined by applying the calculated correction factor as described in the Asphalt Institute SP 2 manual.

Production control for $\% G_{mm}$ at $N_{initial}$ and $N_{maximum}$ shall not exceed the limit shown in Table 2360.3-B2b by more than 1.0 %. Mixture produced beyond these limits, as measured by the moving average of four tests, may result in a cancellation of the Mix Design Report. A new mix design and submittal that satisfies these specification criteria may be required.

E5 Voids Mineral Aggregate (VMA) (calculation)..... Asphalt Institute MS-2, SP-2

E6 Gradation - Blended Aggregate ..... AASHTO T-11, T-27, and T-30 (all Mn/DOT modified)

Testing to determine the blended aggregate gradation shall be determined every 1800 metric tons (**2,000 tons**), or portion thereof (minimum of one per day), on samples taken at the same time as the required mixture sample for a given increment.

All gradations require a - 0.075 mm (**-#200**) wash.

(a) Virgin Aggregate Mixtures - Drum or Screenless Plants Belt Samples or extracted production samples.

(b) All Other Mixtures:

1. Hot Bins - Drybatch (Optional)
2. Incinerator Oven Mn/DOT Laboratory Manual Method 1853 (Optional) except samples that contain over 50% class B. (1)
3. Extraction Mn/DOT Laboratory Manual Method 1851 or 1852 (Optional)

(1) Incinerator Oven may not be used when the percentage of Class B material exceeds 50% within the composite blend, unless a correction factor is determined by the Contractor and approved by the District Materials Engineer.

E7 Coarse Aggregate Angularity ..... ASTM D5821

CAA test results shall meet the minimum percent fractured faces as shown in Table 2360.3-B2a. ASTM D-5821 shall be used to determine coarse aggregate angularity on the composite blend from aggregates used in production of hot mix asphalt. Mixtures that contain virgin aggregates may be tested from composite belt samples. Mixtures that contain RAP must be tested from extracted aggregates taken from standard production samples. The percentage of fractured faces of the composite aggregate blend less than 100% shall be tested at the following rates:

(1) Perform two tests per day for each mixture blend for a minimum of two days and then one per day if the test samples meet CAA requirements.

(2) If CAA crushing test results exceed 8 percent of the requirement, take one sample per day and perform one test per week.

CAA results must be reported on the test summary sheet. Mixture placed and represented by results below the minimum requirement, as shown in Table 2360.3-B2a, will be subject to reduced payment as outlined in Table 2360.4-L3. Tonnage subjected to reduced payment shall be calculated as the tons placed from the sample point of the failing test until the sampling point when the test result is back within specifications.

E8 Fine Aggregate Angularity ..... ASTM C1252 Method A

FAA test results shall meet the minimum criteria shown in Table 2360.3-B2a. ASTM C1252 Method A shall be used to determine fine aggregate angularity on the composite blend from aggregates used in production of HMA. Mixtures that contain virgin aggregates may be tested from composite belt samples. Mixtures that contain RAP must be tested from extracted aggregates taken from standard production samples. The percentage of uncompacted voids from the composite aggregate blend shall be tested at the following rates.

(1) Perform two tests per day for each mixture blend for a minimum of two days and then one per day if the test samples meet FAA requirements.

(2) If FAA test results exceed 5 percent of the requirement, take one sample per day and perform one test per week.

FAA results must be reported on the test summary sheet. Mixture placed and represented by results below the minimums, as shown in Table 2360.3-B2a, will be subject to reduced payment as outlined in Table 2360.4-L3. Tonnage is subjected to reduced payment shall be calculated as the tons placed from the sample point of the failing test until the sampling point when the test result is back within specifications.

E8a - 4.75 mm (-#4) Manufactured Crushed Fines .....(calculation) Mn/DOT Bituminous Manual

Under Marshall design, when the -4.75 mm (**-#4**) crushing is calculated, adjustments in target values from the composite blend must be made at the end of each days paving. If the target quantity (percent of -4.75 mm (**-#4**) to be crushed) changes due to mixture proportion or composite gradation change, a new target shall be established for the next days paving.

E9 Field Tensile Strength Ratio (TSR) .....ASTM D4867 Mn/DOT Modified

A TSR sample shall be obtained within the first 4,500 metric tons (**5,000 tons**) of HMA produced or by the second day of production, whichever comes first, to verify tensile strength ratio (TSR). These samples may be tested at the discretion of the District Materials Engineer. If the Materials Engineer requires the samples to be tested, both the Contractor and the Department will be required to test these samples within 72 hours after it is sampled. Sample size shall be 50 kg (**110 pound**) minimum and split in half to provide a sample for the Department and the Contractor. The Department companion of this split shall be labeled with the date, time, Project number and approximate cumulative tonnage to date. The Department companion shall be given to the Department Street Inspector or Plant Monitor immediately or delivered to the District Materials Engineer

within 24 hours of sampling, as specified by the Engineer. Mixture samples shall be taken from behind the paver unless the Engineer approves an alternate sampling location. Specimen size shall be 100 mm (**4 inch**) for Marshall mix design and 150 mm (**6 inch**) for gyratory design The Contractor may test the sample at a permanent lab site or a field lab site.

Additional HMA mixture samples for TSR evaluation shall be sampled at a rate of 1 per 18,000 metric tons (**20,000 tons**) increments for all mixtures produced on the Project. These samples may be tested at the discretion of the District Materials Engineer. If the Materials Engineer requires the samples to be tested, both the Contractor and the Department will be required to test these samples.

Minimum acceptable TSR values for production are shown in Table 2360.4-E9. The Contractor shall stop production immediately if minimum TSR requirements are not met. The Contractor will not be allowed to resume production until anti-strip has been added to the asphalt binder. Determination of who is responsible for the cost of the anti-strip is based on Mn/DOT and Contractor TSR values as outlined in Tables 2360.4E9A, 2360.4E9B, and 2360.4E9C. When Mn/DOT is responsible for the cost of the anti-strip, payment will be made only for the cost of the anti-strip for mixtures placed on that project. Mn/DOT will not reimburse the Contractor for any delay costs associated with making changes related to this testing.

TABLE 2360.4-E9

Mixture Type- - Minimum TSR					
LV and MV		Gyratory Traffic Level 2-3		Traffic Level 4-5	
Contractor	Mn/DOT	Contractor	Mn/DOT	Contractor	Mn/DOT
70%	60%	75%	65%	80%	70%

TABLE 2360.4-E9A

LV and MV Mixtures		**Contractor TSR**	
		≥70	<70
Mn/DOT TSR	≥60	NA	Mn/DOT
	<60	Contractor	Contractor

TABLE 2360.4-E9B

Gyratory Level 2-3		**Contractor TSR**	
		≥75	<75
Mn/DOT TSR	≥65	NA	Mn/DOT
	<65	Contractor	Contractor

TABLE 2360.4-E9C

Gyratory Level 4-5		Contractor TSR	
		≥80	<80
Mn/DOT TSR	≥70	NA	Mn/DOT
	<70	Contractor	Contractor

Another sample shall be taken and tested within the first 450 metric tons (**500 tons**) after production resumes. If the re-test fails to meet the minimum specified value the Contractor shall stop production immediately. Production cannot resume until the Contractor has discussed, with the Engineer, a proposal for resolving the problem. The Contractor shall not operate below the specified minimum TSR on a continuing basis. A continuing basis shall be defined as 2 or more successive tests failing the TSR requirements.

The following conditions will automatically require a sample to be taken and tested:

1. A proportion change of more than 10 percent (from the currently produced mixture) for a single stockpile aggregate.
2. The discretion of the Engineer.

Dispute resolution procedures for TSR are on file in the Bituminous Office.

E10 Aggregate Specific Gravity (Gsb) .....
.....AASHTO T84 and T85, Mn/DOT modified

Samples of all aggregate stockpiles shall be collected on each aggregate used in the production mixture, at a rate of one sample per 9,000 metric tons (**10,000 tons**) mixture produced. These samples shall be taken at random as directed by the Engineer. These representative stockpile samples shall be 40 kg (**90 pounds**) of each aggregate component. Each sample shall be split in half to provide a sample for the Department and the Contractor. The Department companion shall be labeled with date, time, Project number and approximate cumulative tonnage to date.

The Department companion shall be given to the Department Street Inspector or Plant Monitor immediately or delivered to the District Materials Engineer within 48 hours of sampling, as specified by the Engineer. These samples may be tested. Tested samples will be compared to the Contractor's values on the Mix Design Report. If the results deviate beyond the tolerance specified in Table 2360.4-M, the dispute resolution procedure on file in the Bituminous Office will be utilized. Any mixture placed following notification of new specific gravity values will be based upon Department results unless proven incorrect. The Contractor shall be notified when new specific gravity values become available and what impact this will have on the calculated VMA.

E11 Moisture Content ..... Mn/DOT 5-693.950

Provide a mixture with a moisture content not greater than 0.3 percent. The moisture content in the mixture shall be measured behind the paver or alternate approved sampling method on file in the Bituminous Office. Sampling and testing shall be conducted by the Contractor on a daily basis unless exempted by the Engineer. Sampling and testing is suggested when rain on stockpiles exceed more than 5 mm (**0.2 inch**) in a 24 hour period. The sample shall be stored in an airtight container. Microwave testing is prohibited.

HMA that exceeds 0.3% moisture content is unacceptable. The Contractor shall take appropriate action to remove excess water from the mixture. This action may include reducing the production rate, mixing stockpile aggregates prior to placement into the feed bins, and use of covered stockpiles.

E12 Asphalt Binder Samples

The Contractor shall sample the first shipment of each type of asphalt binder, then sample at a rate of one per 1,000,000 liters (**250,000 gallons**); sample size shall be 1.0 L (**1 quart**). All samples shall be taken in accordance with the Mn/DOT Bituminous Manual 5-693.920. Sampling shall be conducted by Contractor and monitored by the Inspector. Promptly submit the sample to the Department Materials Laboratory in Maplewood. The Contractor shall record sample information on Asphalt Sample Identification Card.

F Documentation (Records)

The Contractor shall maintain documentation, including test summary sheets and control charts, on an ongoing basis. The Contractor shall also maintain a file of gyratory specimen heights for all gyratory compacted samples and test worksheets. Reports, records, and diaries developed during the progress of construction activities for the Project, shall be filed as directed by the Engineer and will become the property of the Department. The Contractor shall:

(1) Number test results in accordance with standard Department procedures and record on forms approved/supplied by the Department.

(2) Facsimile all production test results on test summary sheets to the District Materials Laboratory and to other sites as requested by the Engineer, by 11 AM of the day following production.

(2a) Include the following production test results and mixture information on the Department approved test summary sheet.

1. Percent passing on sieves listed in Table 2360.2-E.
2. Coarse and fine aggregate crushing.
3. Maximum specific gravity ($G_{mm.}$).
4. Bulk specific gravity (G_{mb}).
5. Percent asphalt binder content (P_b).
6. Calculated production air voids (V_a). Gyratory design shall also include %G_{mm} at $N_{initial}$, %G_{mm} at N_{design} , and % G_{mm} at $N_{maximum}$.
7. Calculated voids in mineral aggregate (VMA).
8. Composite aggregate specific gravity (G_{sb}) reflecting current proportions.
9. Aggregate proportions in use at the time of sampling.
10. Tons where sampled.
11. Cumulative tons.
    11a. Tons Represented by Test.
12. Fines to effective asphalt ratio (F/A_e).
13. Signature Line for Mn/DOT and Contractor Representative.
14. Mixture Moisture Content.
15. Mn/DOT verification sample test result.

(2b) Submit copies of all failing test results to the Engineer on a daily basis.

(3) Provide the Engineer with asphalt manifests of BOL's on a daily basis.

(4) Provide a daily plant diary to include a description of QC actions taken (adjustment of cold feed percentages, changes in JMFs, etc.) include all changes or adjustments on the test summary sheets.

(5) Provide weekly truck scale spot checks.

(6) Provide a Department approved accounting system for all mixes and provide a daily and final Project summary of material quantities and types.

(6a) Provide a final hardcopy summary of all quality control test summary sheets and control charts at completion of bituminous operations on the Project to the Engineer. Because Certified Plant test data often represents test data for multiple projects, it may be necessary to make duplicate copies of the data for each project. The Contractor shall also submit a diskette of the quality control summary sheets, control charts and density worksheets to the Bituminous Engineer.

(7) Furnish an automated weigh scale and computer generated weigh ticket. The ticket shall indicate project number, mix designation (including binder grade), Mixture Design

Report#, truck identification and tare, net mass, date and time of loading. Any deviations from the minimum information to be provided on the computer generated weigh ticket must be approved by the Engineer in writing.

(8) Charts and records for a mixture produced at one plant site shall be continued from contract to contract.

G Documentation (Control Charts)

The following data shall be recorded on the standardized control charts, all control charts and summary sheets shall be computer generated using software approved by the Engineer. Software is available from the Mn/DOT Bituminous Office website.

(1) Blended aggregate gradation, include sieves shown in Table 2360.2-E for specified mixture.
(2) Percent asphalt binder content (P_b).
(3) Maximum specific gravity ($G_{mm.}$).
(4) Production air voids (V_a).
(5) VMA.

Individual test results shall be plotted for each test point. A solid line shall connect individual points. The moving average for each test variable shall be plotted starting with the fourth test. A dashed line shall connect the moving average points. The Department's quality assurance and verification test results shall be plotted with asterisks. Specification JMF limits shall be indicated on the control charts using a dotted line. The Engineer may waive the plotting of control charts.

H JMF Limits

The production air voids and VMA are based upon the minimum specified requirements as shown in Tables 2360.3-B2b and 2360.3B2c. Gradations and asphalt binder content limits are based upon the current Department reviewed Mixture Design Report. Gradation control sieves include each sieve shown in Table 2360.2-E. The mixture production targets are listed on the Mixture Design Report. JMF limits are the target plus or minus the limits shown in Table 2360.4-H. JMF limits are used as the criteria for acceptance of materials based on the moving average. A moving average is the average of the last four test results.

I JMF Bands

JMF Bands are defined as the area between the target, as identified on the Mixture Design Report, and the JMF limits.

TABLE 2360.4-H
JMF LIMITS (N=4)

Item	JMF Limits
VMA, %	- 0.3
Production Air Voids, %	± 1.0
Asphalt Binder Content, %	- 0.4
Sieve - % Passing*	
25, 19, 12.5, 9.5, 4.75 mm (**1 inch, ¾ inch, ½ inch, 3/8 inch, #4**)	± 7
2.36 mm (**#8**)	± 6
0.075 mm (**#200**)	± 2.0

*****JMF limits are not allowed outside the broadband requirements in Table 2360.2-E.

J JMF Adjustment

The Contractor shall begin mixture production with the materials (gradation, asphalt content, and aggregate proportions) closely conforming to the reviewed Mixture Design Report. Closely conforming shall be defined as aggregate proportions within 5 percent of the design proportions [(1)] and other mixture parameters within the JMF limits in Table 2360.4-H. This requirement may be waived if the Contractor provides the District Materials Laboratory with prior documented production data showing how production affects the mixture properties or if the Contractor provides the District Materials Laboratory with a written justification or explanation of material changes since the original mixture submittal.

[(1)]The Contractor shall begin mixture production using all aggregate proportions included on the Mixture Design Report unless the aggregate proportion is shown as 0 percent.

If, during production, the Contractor determines from results of QC tests that adjustments to the mix design are necessary to achieve the specified properties, the following provisions shall apply. No adjustments are allowed using aggregates or materials not part of the original mix design.

The Contractor shall make a request for a JMF adjustment to the Department Bituminous Engineer or District Materials Engineer. The requested change will be reviewed for the Department by a Certified Level II Bituminous QM Mix Designer. If the request meets the design requirements in Tables 2360.3-B2a and 2360.3-B2b, a revised Mixture Design Report shall be issued. Each trial mixture design submittal as described in Section 2360.3A may have three JMF adjustments per mixture per project without charge. Additional JMF adjustments requested must be accompanied with a $500 fee per each additional JMF adjustment, payable to the Commissioner of

Transportation.

If a JMF change is requested for the 0.075 mm (**#200**) sieve, the Fines to Effective Asphalt Ratio shall be determined on the moving average from the previous four gradation tests conducted during actual production. The adjusted JMF shall be within the mixture specification gradation design broadbands shown in Section 2360.2E. Should a redesign of the mixture become necessary, a new JMF shall be submitted. The JMF asphalt content may only be reduced if the production VMA meets or exceeds the minimum VMA requirement for the mixture being produced.

Adjustments will be made as a result of an interactive process between the Contractor, Engineer, and District Materials Engineer. Consecutive requests for JMF adjustments, without production data, are not allowed. The calculation of the moving average shall continue after the JMF has been approved.

J1 JMF Adjustment for Proportion Change > 10%

If a JMF adjustment is requested for a proportion change exceeding 10% (from the currently produced mixture) for a single stockpile aggregate, supporting production test data from a minimum of four tests run at an accelerated testing rate of 1 test per 450 metric tons (**500 tons**) must be included with the request for adjustment. In addition to the requirements listed above, acceptable verification and approval of the requested JMF will be based on individual and moving average test results. Individual test results must be within twice the requested JMF limits for percent asphalt binder, production air voids, and VMA. Individual gradation must be within twice the requested JMF bands. The moving average values must be within the control limits of Table 2360.4-H . The calculation of the moving average shall continue after the change in proportions.

If the mixture meets the specified quality indicators, the request for JMF adjustment will be signed by the District Materials Laboratory and considered effective from the point the proportion change was made. Failure to meet the quality indicators will result in reduced payment or removal and replacement with acceptable material. Consecutive requests for JMF adjustments without production data is not allowed.

K Corrective Action -- Percent Asphalt Binder Content, VMA, and Gradation and Production Air Voids

When the moving average values trend toward the JMF limits, the Contractor shall take corrective action. The corrective action taken shall be documented on summary sheets and, if applicable, a request for JMF adjustment shall be submitted to the District Materials Engineer for review and approval. All tests shall be part of the project files and shall be included in the moving average

calculations. The Contractor shall notify the Engineer whenever the moving average values exceed the JMF limits**.**

L Failing Materials

The determination of price adjustments for failing materials will be based on the criteria outlined in this Section. Material acceptance is based on individual and moving average test results. Isolated test results are used for acceptance of air voids at the start of mixture production. Generally, individual test results which are more than twice the JMF bands are considered failing. Moving average test results are considered failing when they exceed the JMF limits.

If the moving average values exceed the JMF limits, the Contractor shall stop production and make adjustments. The Contractor shall restart production only after notifying the Engineer of the adjustments that have been made. Testing shall resume at the accelerated rates and for the tests listed in Table 2360.4-D for the next 1800 metric tons (**2,000 tons**) of mixture produced. The calculation of the moving average shall continue after the stop in production.

Mixture produced where the moving average of four exceeds the JMF limits shall be considered unsatisfactory and subject to requirements of Section 2360.4L4, L5, L6, and L7. Individual test failures are discussed in Section 2360.4L1, L2, and L3.

When the total production of a mixture type for the entire project requires less than four tests, a moving average will be established based on the tests taken. Acceptance of material will be consistent with the criteria outlined in Section 2360.4L and will be based on the following modifications to the JMF limits: For two tests, establish the new JMF limits by multiplying the JMF limits listed in Table 2360.4-H by 1.41; for three tests, establish the new JMF limits by multiplying the JMF limits listed in Table 2360.4-H by 1.15. For moving average gradation, the modified JMF limit cannot exceed the broadband requirements in Table 2360.2-E.

When the Contractor's testing data fails to meet specified tolerances as listed in Table 2360.4-M, quality assurance/verification data shall be used in place of the Contractor's data to determine the appropriate payment factor.

L1 Isolated Failures at Mixture Start-Up – Production Air Voids

At the start-up of mixture production, before a moving average of four can be established the first three (3) isolated test results for production air voids will be used for acceptance. Isolated production air voids are calculated by using the maximum mixture specific gravity and the corresponding bulk specific gravity from that single test. After four (4) samples have been tested and a moving average of four can be established, acceptance will be based on individual and

moving average production air voids.

If, at the start of production, any of the first three (3) isolated test results for production air voids exceeds twice the JMF bands from the target listed on the Mixture Design Report, the material is considered unsatisfactory or unacceptable. Reduced payment as outlined in Table 2360.4-L3 shall apply to all tonnage placed from the sample point of the failing test until the sample point when the isolated test result is back within twice the JMF bands. When the failure occurs at the first test, after the start of production, the tonnage subjected to reduce payment shall be calculated as described above and shall include the tonnage from the start of production.

When isolated air voids are less than 1.0% or greater than 7.0% the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. To better define the area to be removed and replaced the Engineer may require the Contractor to test inplace mixture. This may include testing mixture placed prior to the failing test result. Reduced payment will be 50 percent of the Contract bid price.

L2 Individual Failure at Mixture Start-Up – VMA

At the start-up of mixture production, before a moving average of four can be established, the first three (3) individual test results for VMA will be used for acceptance. After 4 samples have been tested and a moving average of four can be established, acceptance will be based on individual and moving average VMA.

If, at the start of production, any of the first three (3) individual VMA test results exceeds twice the JMF bands from the target listed on the Mixture Design Report, the material is considered unsatisfactory or unacceptable. Reduced payment as outlined in Table 2360.4-L3 shall apply to all tonnage placed from the sample point of the failing test until the sample point when the test results are back within twice the JMF limits. When the failure occurs at the first test, after the start of production, the tonnage subjected to reduce payment shall be calculated as described above and shall include the tonnage from the start of production.

L3 Individual Failure - Gradation, Percent Asphalt Binder, Production Air Voids, and VMA

If the individual gradation test exceeds twice the JMF bands from the target listed on the Mixture Design Report the material is considered unsatisfactory or unacceptable. Reduced payment as outlined in Table 2360.4-L3 shall apply to all tonnage represented by the individual test.

TABLE 2360.4-L3
REDUCED PAYMENT SCHEDULE FOR INDIVIDUAL TEST RESULTS

Item	Pay Factor [1]
Gradation	95 %
Coarse and Fine Aggregate Crushing	90 %
VMA	85 %
Asphalt Binder Content	85 %
Production Air Voids (individual [2] and isolated [3])	70 %

[1] Lowest Pay Factor applies when there are multiple reductions on a single test.

[2] Individual air voids are calculated using the moving average maximum specific gravity and the bulk specific gravity from that single test.

[3] Isolated air voids are calculated from the maximum specific gravity and the bulk specific gravity from that single test. Isolated void test results are used for acceptance only for the first 3 tests after mixture production start-up.

If the individual tests for percent asphalt binder content, production air voids, or VMA exceeds twice the JMF bands from the target listed on the Mix Design Report the material is considered unsatisfactory or unacceptable. Reduced payment as outlined in Table 2360.4-L3 shall apply to all tonnage placed from the sample point of the failing test until the sample point when the test result is back within twice the JMF limits. When the failure occurs at the first test after the start of daily production, tonnage subjected to reduced payment shall be calculated as described above and shall include the tonnage from the start of production that day.

When individual air voids are less than 1.0% or greater than 7.0% the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. To better define the area to be removed and replaced the Engineer may require the Contractor to test inplace mixture. This may include testing mixture placed prior to the failing test result. Reduced payment will be 50 percent of the Contract bid price.

L4 Moving Average Failure at Mixture Start-Up – Production Air Voids

When a moving average failure occurs within any of the first 3 moving average results after mixture start-up (tests 4, 5, 6), the mixture will be considered acceptable if the individual air void, corresponding to the moving average failure is within the JMF limits. If the individual air void is not within the JMF limit, the mixture will be considered unacceptable and the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. The Engineer may waive the penalty if the isolated air void corresponding to the individual air void is within the JMF limit. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. Reduced payment will be 50 percent of the Contract bid price. Tonnage subjected to replacement or reduced payment shall be calculated as the tons placed from the sample point of the failing moving average result and corresponding individual air void beyond the JMF limit to the sampling point when the individual test result is back within the JMF limit.

L5 Moving Average Failure at Mixture Start-Up - VMA

When a moving average failure occurs within any of the first 3 moving average results after mixture start-up (tests 4, 5, 6), the mixture will be considered acceptable if the individual VMA, corresponding to the moving average failure is within the JMF limits. If the individual VMA is not within the JMF limit, the mixture will be considered unacceptable and the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. Reduced payment will be 75 percent of the Contract bid price. Tonnage subjected to replacement or reduced payment shall be calculated as the tons placed from the sample point of the failing moving average result and corresponding individual VMA beyond the JMF limit to the sampling point when the individual test result is back within the JMF limit.

L6 Moving Average Failure - Production Air Voids

A moving average production air void failure occurs when the individual production air void moving average of four exceeds the JMF limit. This mixture is considered unacceptable and the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. Reduced payment will be 50 percent of the Contract bid price. Tonnage subjected to replacement or reduced payment shall be calculated as the tons placed from the sample point of all individual test results beyond the JMF limits which contributed to the moving

average value that exceeded the JMF limit to the sampling point when the individual test result is back within the JMF limits. When the failure occurs at the first test after the start of daily production, tonnage subjected to reduced payment shall include the tonnage from the start of production that day.

TABLE 2360.4-L6
REDUCED PAYMENT SCHEDULE FOR MOVING AVERAGE TEST RESULTS

Item	**Pay Factor** [1]
Gradation	75 %[3]
Coarse and Fine Aggregate Crushing	NA (individual failures only)
VMA[2]	75 %
Asphalt Binder Content	75 %
Production Air Voids[2]	50 %

[1] Lowest Pay Factor applies when there are multiple reductions on a single test.
[2] See criteria for mixture production start-up.
[3] Excluding the 0.075 mm (**#200**) sieve, use 95% pay factor if failure is within ± 1% of aggregate gradation broadband, Table 2360.2-E.

L7 Moving Average Failure - Percent Asphalt Binder Content, VMA, and Gradation

For mixture properties including asphalt binder content, VMA, and gradation, where the moving average of four exceeds the JMF limits, the mixture is considered unacceptable and the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. Reduced payment will be 75 percent of the Contract bid price. Tonnage subjected to replacement or reduced payment shall be calculated as the tons placed from the sample point of all individual test results beyond the JMF limits which contributed to the moving average value that exceeded the JMF limit, to the sampling point when the individual test result is back within the JMF limits. When the failure occurs at the first test after the start of daily production, tonnage subjected to reduced payment shall include the tonnage from the start of production that day.

L8 Coarse and Fine Aggregate Crushing Failure

If any test result for Coarse Aggregate Angularity, Fine Aggregate Angularity or -4.75mm (**- #4**) calculated crushing fail to meet minimum requirements in Table 2360.3-B2a, all material placed

is subject to reduced payment as outlined in Table 2360.4-L3. Tonnage subjected to reduced payment shall be calculated as the tons placed from the sample point of the failing test until the sampling point when the test result is back within specifications. When the failure occurs at the first test after the start of daily production, tonnage subjected to reduced payment shall include the tonnage from the start of production that day.

M Quality Assurance

The Engineer will periodically witness the sampling and testing being performed by the Contractor. If the Engineer observes that the sampling and quality control tests are not being performed in accordance with the applicable test procedures, the Engineer may stop production until corrective action is taken. The Engineer will notify the Contractor of observed deficiencies promptly, both verbally and in writing.

The Engineer may obtain additional samples, at any time, to determine quality levels. These additional samples or verification samples are described in Section 2360.4N. For mixture, the Contractor shall test their portion immediately.

All testing and data analysis shall be performed by the Certified Level I Bituminous Quality Management (QM) Technician. Certification shall be in accordance with the Mn/DOT Technical Certification Program. The Department shall post a chart giving the names and telephone numbers for the personnel responsible for the Quality assurance program.

The Engineer shall calibrate and correlate all laboratory testing equipment in accordance with the latest version of the Mn/DOT Bituminous Manual.

N Verification Testing

A verification sample is a sample, which is sampled and tested by Mn/DOT to assure compliance of the Contractor's Quality Control program. A verification companion is a companion sample, to Mn/DOT's verification sample, provided to the Contractor. The Contractor is required to test and use this verification companion sample as part of the QC program. The verification companion sample will replace the next scheduled QC sample. It is recommended enough material be sampled to accommodate retesting should the samples fail to meet requirements as described below.

TABLE 2360.4-M
ALLOWABLE DIFFERENCES (TOLERANCES) BETWEEN CONTRACTOR AND MN/DOT TEST RESULTS*

Item	**Allowable Difference**
Mixture Bulk Specific Gravity (G_{mb})	0.030
Mixture Maximum Specific Gravity (G_{mm})	0.019
VMA (Calculated)	1.2
Fine Aggregate Angularity, uncompacted voids (U) %	1
Coarse Aggregate Angularity, % fractured faces (%P)	15
Aggregate Individual Bulk Specific Gravity (+4.75mm (+ **#4**))	0.040
Aggregate Individual Bulk Specific Gravity (-4.75mm (**- #4**))	0.040
Aggregate combined blend Specific Gravity (G_{sb})	0.020
Tensile Strength Ratio (TSR) %	See Table 2360.3-B2b
Asphalt Binder Content	
Meter Method, %	0.2
Spot Check Method, %	0.2
Chemical Extraction Methods, %	0.4
Incinerator Oven, %	0.3
Chemical vs. Meter, Spot Check, or Incinerator methods	0.4
Incinerator Oven vs. Spot Check	0.4
Gradation Sieve % passing	
25.0, 19.0, 12.5, 9.5 mm (**1 inch, ¾ inch, ½ inch, 3/8 inch**)	6
4.75 mm (**#4**)	5
2.36 mm (**#8**)	4
0.075 mm (**#200**)	2.0

*Test tolerances listed are for single test comparisons.

Verification testing shall be performed on at least one set of production tests Section 2360.4E, excluding sections E9, E10, E11, and E12, on a daily basis per mix type. The verification companion sample will be used to verify the requirements of Tables 2360.2-E, 2360.3-B2a, 2360.3-B2b, and 2360.3-B2c and will be compared to the Verification sample for compliance with allowable tolerances as specified in Table 2360.4-M. These include the mixture properties of

G_{mm} (mixture max gravity), G_{mb} (mixture bulk gravity), asphalt binder content, VMA (calculated), Coarse and Fine Aggregate crushing, and gradation. For Coarse and Fine Aggregate crushing that meets the requirements of Section 2360.4E7 and 2360.4E8 the one test per week shall be performed on a verification companion. These do not include the aggregate bulk specific gravity $G_{sb,}$ fines to effective asphalt, or the tensile strength ratio (TSR). Asphalt binder content and gradation must be determined by either extraction method 2360.4E1b or 2360.4E1c. Asphalt content from the verification test result must be used to determine VMA.

The Department's verification test results will be available to the Contractor within 2 working days from the time the sample is delivered to the District Laboratory for Gmm mixture max gravity, Gmb mixture bulk gravity, air voids (calculated), asphalt binder content, VMA (calculated). Gradation and crushing results will be provided to the Contractor within 3 Mn/DOT working days. Once the verification test results are available, they will be included on the test summary sheet. These results and those from the Contractor's verification companion will be compared for allowable tolerances as specified in Table 2360.4-M. If the tolerances are met, the verification process is complete.

If the tolerances between Department and Contractor are not met, retests of the material shall be conducted by the Department. If the retests fail to meet tolerances, the Department's verification test results will be substituted for the Contractor's results in the QC program and used for acceptance. Only those parameters out of tolerance will be substituted and, if applicable, volumetric properties will be recalculated [(1)].

When tolerances from the verification sample retests are not met, an investigation will begin immediately to determine the cause of the difference. Testing equipment, procedures, worksheets, gyratory specimen height sheets, and personnel will be reviewed to determine the source of the problem. The District Materials Engineer may also require a hot-cold comparison of mixture properties be performed. The procedure for hot-cold comparisons is as follows:

> The hot-cold comparison sample will be split into three representative portions. The Engineer will observe the Contractor testing the sample. One part shall be compacted immediately while still hot (additional heating maybe required to raise the temperature of the sample to compaction temperature). The second and third part will be allowed to cool to air temperature. The Contractor will retain the second part and the third part will be transported to the District Materials Laboratory. On the same day and at approximately the same

time the Contractor and the District Materials Laboratory will heat their samples to compaction temperature and compact them. From this information a calibration factor will be developed to compare the specific gravity of the hot compacted samples to reheated compacted samples. Each test will involve a minimum of three Marshall specimens or two gyratory specimens. This test may be repeated at the discretion of the Contractor or the District Materials Engineer.

Note: Care must be taken when reheating samples for mixture properties analysis tests. Mix samples should be reheated to 70°C (**160°F**) to allow splitting of the sample into representative fractions for the various tests. Overheating of the mixture portions to be tested for maximum specific gravity (Rice Test) may result in additional asphalt being absorbed in the aggregate.

The Department will test the previously collected QA samples until they meet the tolerances or the remaining samples are all tested. Once these samples are tested, the department will test QA samples subsequent to the verification sample until tolerances are met. Acceptance will be based on QC data with substitution of Department test results for those parameters out of tolerance [(1)]. If reestablishment of test result tolerances is not achieved within 48 hours, the Contractor shall cease mixture production and placement until the problem is resolved.

[(1)] If, through analysis of data, it is determined there is a bias in the test results, the Engineer will determine which results are appropriate and shall govern. Methods to analyze data for determination of bias are on file in the Bituminous Office.

2360.5 CONSTRUCTION REQUIREMENTS

A General

The following construction requirements provide for the construction of all courses. When construction is under traffic, the requirements of Mn/DOT 2221.3D will apply.

B Restrictions

In general, no work within the roadway will be permitted in the spring until seasonal load restrictions on roads in the vicinity have been removed. However, work within the roadbed may be permitted before that time if, in the opinion of the Engineer, it can be done without damage to the subgrade. HMA shall not be placed when, in the opinion of the Engineer, the weather or roadbed conditions are unfavorable.

No asphalt pavement wearing course (final wearing course if multiple wearing courses) shall be placed after October 15th in that part of the state north of an east-west line between Browns Valley and Holyoke, nor after November 1st south of that line. The Engineer may waive these restrictions when:

(1) The asphalt mixture is not being placed on the traveled portion of the roadway, or
(2) The roadway involved will not be open to traffic during the following winter, or
(3) The Engineer directs in writing the mixture be placed.

The Contractor shall not use petroleum distillates such as kerosene and fuel oil to prevent adhesion of asphalt mixtures in pavement hoppers, truck beds, or on the contact surfaces of the compaction equipment. Anti-adhesive agent must meet the criteria for "Effect on Asphalt" as described in the most recent Asphalt Release Agent Report on file in Mn/DOT's Office of Environmental Services and the Bituminous Office.

C Equipment

C1 Asphalt Mixing Plants

C1a Requirement for All Plants

The Contractor shall test and calibrate all scales according to Mn/DOT 1901, except as otherwise designated by the Contract.

C1a(1) Equipment for the Preparation of the Aggregate

Add mineral filler to the mixture using a storage silo equipped with a device to ensure a constant and uniform feed.

C1a(2) Equipment for the Preparation of Asphalt Material

Tanks for storage of asphalt material at the plant shall be equipped to heat the material and maintain the material at the required temperatures. The discharge end of the circulating line shall be below the surface of the asphalt material. Provide agitation for modified asphalt, when used, if recommended by the supplier.

An outage table or chart and measuring stick shall be provided for each storage or working tank. Tanks shall be equipped with provisions for taking of asphalt binder material samples. After delivery of asphalt binder material to the Project, the Contractor shall not heat the material above 175°C (**350°F**). For modified asphalt, the maximum storage temperature shall not exceed the recommendation of the asphalt supplier.

C1a(3) Asphalt Binder Control

When asphalt binder material is proportioned by volume, the plant shall be equipped with either a working tank or a metering system for determining asphalt binder content of the mixture.

The working tank shall have a capacity between 3,800 L (**1,000 gallons**) and 7,600 L (**2,000 gallons**). The working tank shall be

calibrated and supplied with a calibrated measuring stick. The tank may be connected to a mixing unit and used only during spot check operations, but it shall be available at all times. Any feedback shall be returned to the working tank during spot check operations.

The metering system shall consist of at least one approved asphalt binder flow meter in addition to the asphalt binder pump. The flow meter shall be connected to the asphalt binder supply to measure and display only the asphalt binder being fed to the mixer unit. The meter readout shall be positioned for convenient observation. Means shall be provided for comparing the flow meter readout with the calculated output of the asphalt binder pump. In addition, the system shall display in liters (**gallons**) or to the nearest 0.001 metric tons (**0.001 tons**), the accumulated asphalt binder quantity being delivered to the mixer unit. The system shall be calibrated and adjusted to maintain an accuracy of $\pm$ one percent error. This calibration shall be required for each plant set-up prior to production of mixture.

C1a(4) Dryer: The aggregate shall be free of unburned fuel.

C1a(5) Thermometric Equipment:

The plant shall be equipped with a sufficient number of thermometric instruments to ensure temperature control of the aggregate and the asphalt binder material.

C1a(6) Pollution Controls

C1a(6)(a) Pollution 1717

C1a(7) Surge and Storage Bins

The plant may include facilities to store hot asphalt mixture for coordinating the rate of production with the paving operations. Storage of the hot mixture will be permitted for a period not to exceed 18 hours, provided the following requirements are met:

(a) Hot mix storage facilities shall be designed and operated to prevent segregation of the mix, drainage of the asphalt from the mix, and to prevent excessive cooling or overheating of the mixture.

(b) The temperature of the mixture at time of discharge from the storage facility shall be within a tolerance of 5°C (**9°F**) of the temperature when discharged from the silo or mixer.

C2 Placement and Hauling Equipment

All equipment shall be serviced away from the paving site to prevent contamination of the mixture. Units that drip fuel, oil, or grease shall be removed from the paved surface until such leakage is corrected.

C2a Asphalt Pavers

Asphalt pavers shall be self-contained, power-propelled units, with an operational vibratory screed, capable of spreading and

finishing courses of asphalt plant mix material in widths applicable to the specified typical sections and thicknesses, indicated in the Contract.

The screed or strike-off assembly shall produce a finished surface of the required evenness and texture without tearing, shoving, or gouging. For mainline paving, screed extensions and auger extensions are required if the paving width on either side of the paver is greater than the basic screed unless otherwise directed by the Engineer. Strike-off only extension assemblies are not allowed for mainline wearing course paving, unless directed by the Engineer.

Automatic screed control by means of an erected string line shall only be required when stated in the Contract.

All pavers shall be equipped with an approved automatic screed control. The automatic controls shall include a system of sensor-operated devices, which follow reference lines, or surfaces on one or both sides of the paver as required. The speed of the paver shall be adjusted to produce the best results.

All mixtures shall be spread without segregation to the cross sections shown in the plans. In general, leveling layers shall be spread by the method producing the best results as approved by the Engineer. The objective is to secure a smooth base of uniform grade and cross section so that subsequent courses will be uniform in thickness. The leveling layer may be spread with a properly equipped paver or, when approved by the Engineer, a motor grader equipped with a leveling device, or with other means for controlling the surface elevation of the leveling layer.

All mixtures shall be spread, to the fullest extent practicable, by an asphalt paver. When approved by the Engineer, mixtures may be spread by a motor grader in areas that are inaccessible to a paver such as on driveway entrances, irregular areas, short isolated areas or when the quantity of mixture makes it impractical to place with a paver.

On shoulder surfacing and uniform width widening, when the placement width is too narrow for a paver, the mixture in each course shall be spread with an approved mechanical device.

The placement of each course shall be completed over the full width of the section under construction on each day's run unless otherwise directed by the Engineer.

C2b Trucks

Trucks for hauling asphalt mixtures shall have tight, clean, and smooth beds. Mixture shall not be allowed to adhere to the truck beds. Adherence may be prevented by spraying the truck bed with an anti-adhesive agent in accordance with Section 2360.5B. Each truck shall be equipped with a cover of canvas or other suitable material to protect the mixture from weather. The cover shall extend at least

300 mm (**1 foot**) over the sides and be attached to tie-downs unless the truck is furnished with a mechanical or automated covering system, which prevents airflow underneath by stretching the cover tightly on the top of or inside the sideboards. The cover shall be used when directed by the Engineer.

C2c Motor Graders

Motor graders shall be self-propelled and have pneumatic-tires with a tread depth of 13 mm (**½ inch**) or less. They shall be equipped with a blade not less than 3 m (**10 feet**) in length and shall have a wheelbase of not less than 4.5 m (**15 feet**).

D Treatment of the Surface

D1 Tack Coat

An asphalt tack coat shall be applied to existing asphalt and concrete surfaces, and to the surface of each course or lift constructed, except for the final course or lift, according to Mn/DOT 2357. Emulsified asphalt tack coats shall be allowed to break, as indicated by a color change from brown to black, before a subsequent lift is placed.

The contact surfaces of all fixed structures and the edge of the in-place mixture in all courses at transverse joints and longitudinal joints shall be given a uniform but not excessive coating of liquid asphalt or emulsified asphalt before placing the adjoining mixture.

E Compaction Operations

After being spread, each course shall be compacted to the required density. The rollers shall, as practicable, be operated continuously so all areas are thoroughly compacted to the required density. When not operating, the rollers shall not stand on the uncompacted mixture or newly rolled pavement having a surface temperature exceeding 60°C (**140°F**). Rolling with steel-wheeled rollers shall be discontinued if it produces excessive crushing or pulverizing of the aggregate or displacement of the mixture.

To prevent adhesion of the mixture to the steel roller wheels, the contact surfaces of the wheels shall be kept properly moistened using water or a water solution containing small quantities of a detergent or other approved material.

To secure a true surface, variations such as depressions or high areas, which may develop during rolling operations, and lean, fat or segregated areas shall be corrected by removing and replacing the material in the defective area. All such corrections shall be accomplished as directed by the Engineer at no expense to the Department.

When mixtures are spread by a motor grader, pneumatic-tired rollers shall compact the mixture simultaneously with the spreading operation.

F Construction Joints

Joints shall be thoroughly compacted to produce a neat, tightly bonded joint that meets surface tolerances. Both transverse and longitudinal joints are subject to density requirements as outlined in Section 2360.6 Pavement Density.

F1 Transverse Joints

A transverse joint (full paver width at right angles to the centerline) shall be constructed when mixture placement operations are suspended. The forward end of the freshly laid strip shall be thoroughly compacted by rolling before the mixture has cooled. When work is resumed, the end shall be cut vertically for the full depth of the layer unless a formed edge is constructed as approved by the Engineer.

F2 Longitudinal Joints

Longitudinal joints between strips shall be parallel to the centerline. In multiple lift construction, the longitudinal joints between strips in each lift shall be constructed not less than 150 mm (**6 inches**) measured transversely from the longitudinal joints in the previously placed lift. When the wearing course is constructed in an even number of strips, one longitudinal joint shall be on the centerline of the road. When it is constructed in an odd number of strips, the centerline of one strip shall be on the centerline of the road, provided that no joint is located in the wheel path area of a traffic lane. Longitudinal joints in multiple lift construction over Portland cement concrete pavements may be aligned directly over the concrete pavement longitudinal joints at the discretion of the Engineer.

At longitudinal joints formed by placing multiple strips, the adjoining surface being laid shall, after final compacting, be slightly higher (but not to exceed 3 mm (**1/8 inch**)) than the previously placed strip. When constructing a strip adjoining a previously placed strip or a concrete pavement, any fresh mixture that overlaps a previously placed strip or pavement shall be removed (to the longitudinal joint line) before any rolling is done.

G Asphalt Mixture Production (FOB Department Trucks)

For asphalt mixture production, the Contractor shall, in addition to the asphalt mixture required on the Project, produce and deliver asphalt mixture to the Department. The mixture shall be the mixture being produced and shall be loaded on Department furnished trucks at the mixing plant at a time agreed on by the Engineer and Contractor. The Engineer will notify the Contractor of the total quantity of mixture desired not less than 2 weeks prior to completion of the wearing course construction. The Engineer will not accept the asphalt mixture if it is inappropriate for the Department's intended use.

H Small Quantity HMA Paving

Unless otherwise indicated in the Special Provisions, the following provision for a small quantity of asphalt mixture shall apply.

A Mixture Design Report is not required for planned project quantities less than 191,200 m^2 mm (**9,000 square yard inches (4,500 square yards per 2 inch thickness, etc**)) or 450 metric tons (**500 tons**). However, the Contractor shall verify in writing the asphalt mixture delivered to the project meets the requirements of Table 2360.3-B2a and Table 2360.3B2b. The Department will obtain samples, as determined by the Engineer, to verify percent design air voids and gradation. These results will be used for material acceptance. Air voids will be subject to the requirements of Section 2360.4L1b for isolated air voids and a gradation falling outside the requirements of Table 2360.2-E will be subject to payment as indicated in Table 2360.4-L2b.

2360.6 PAVEMENT DENSITY

A General

All pavements will be compacted in accordance with the Maximum Density Method unless otherwise specified in the Contract special provisions or as noted in Section 2360.6C.

B Maximum Density Method

All courses or layers of plant mixed asphalt mixtures for which the Maximum Density Method is used shall be compacted to a density not less than the percentage shown in the Table of Required Density, Table 2360.6-B2, for the applicable mixture and course.

B1 Maximum Density Determination

The Density requirements listed in Table 2360.6B2 are percent of maximum specific gravity (G_{mm}) based on the individual lot. The Maximum specific gravity value used to calculate the percentage density for the lot shall be the average value obtained from the maximum gravity results from production tests taken during that days paving. If only one or two maximum specific gravity values were obtained that day, then the moving average value (at that test point) shall be used. If three or more maximum specific gravity values are obtained that day, then the average of those tests alone shall be used as indicated above.

B1a Pavement Density Determination

The density of each lot shall be expressed as a percentage of the maximum specific gravity (% G_{mm}) obtained by dividing the average bulk specific gravity for the lot by the maximum specific gravity multiplied by 100, (maximum specific gravity basis is the average G_{mm} of QC tests done on the day that the individual lot was paved as described above). Determination of the bulk specific gravity of the cores shall be in accordance with AASHTO T-166, Mn/DOT modified. For coarse graded mixtures the Engineer may require determination of bulk specific gravity of the cores be in accordance with ASTM D1188, Mn/DOT modified. ASTM D6752 Mn/DOT modified (Corelok) is also allowed for determination of bulk specific gravity of coarse graded mixtures. Selection of the test method to determine coarse graded mixture bulk specific gravity shall be agreed upon at the time of mix design submittal. Both the Contractor and Mn/DOT shall use the same test method to determine bulk specific gravity. The determination of coarse and fine graded mixtures will be based on the percentage of material passing the 2.365 mm sieve (**#8**) as defined in Table 2360.3-B2c.

Compaction operations shall be completed within 8 hours of mixture placement and before core samples are obtained for density determination. Only pneumatic tired or static steel rollers are permitted for any compactive effort performed between 6 and 8 hours after mixture placement.

Compacted mixtures represented by samples or tests having deficient densities shall not be re-rolled. The Contractor shall not operate below the specified minimum density on a continuing basis. A continual basis shall be defined as all lots in a day's production failing to meet minimum density or more than 50% of lots on multiple days which fail to meet minimum density requirements. Production shall be stopped until the source of the problem is determined and corrective action is taken to bring the work into compliance with specified minimum required density.

B2 Required Density

Minimum density requirements for both gyratory (SP) and Marshall designed mixtures are listed in Table 2360.6-B2.

Unless otherwise indicated in the Plans or Special Provisions, shoulders wider than 1.8 meters (**6 feet**) paved shall be compacted by the Maximum Density Method. When shoulders are required to be compacted by the Maximum Density Method and are paved in a separate operation or have a different required minimum density than the driving lane, the lot tonnage placed on the shoulder shall be delineated in separate lots from the driving lanes for the day paving was conducted.

Unless otherwise indicated in the Plans or Special Provisions a narrow shoulder, 1.8 meter (**6 feet**) or less wide, that is paved in the same pass as a driving lane or that is paved separately will be compacted by the Ordinary Compaction Method. Mixture compacted under Ordinary Compaction is excluded from lot density requirements and that tonnage is also excluded from incentive/disincentive payment.

If the Plans or Special Provisions indicate a narrow shoulder is to be compacted by the Maximum Density Method, the minimum required density is listed in Table 2360.6-B2. If the minimum required density of the shoulder is different than the driving lane, the tonnage placed on the shoulder shall be delineated in separate lots from the driving lane.

Echelon paving (two pavers running next to each other in adjacent lanes) shall be considered separate operations.

TABLE 2360.6-B2
REQUIRED MINIMUM DENSITY

	SP Wear and All MV and LV Mixtures (1)(2)	**SP Nonwear** (1)(2)	**SP Shoulders** (1)(2)	
Location from surface*	≤ 100 mm (**4 inch**)**	> 100 mm (**4 inch**)**	Designed at 3% voids	Designed at 4% voids
% Gmm	92.0	93.0	93.0	92.0

* SP Mixtures only

** If less than 25% of a layer is within 100 mm (**4 inches**) of the surface, the layer may be considered to be below 100 mm (**4 inches**) for mix design purposes.

(1) Minimum reduced by one percent on the first lift constructed over PCC pavements.

(2) Minimum reduced by one percent for the first lift constructed on aggregate base (mainline and shoulder), reclaimed or cold inplace recycled base courses and first lift of an overlay on a roadway with a 6.35 metric ton (**7 ton**) or less spring load restriction (roadway includes shoulders).

B2a Lots & Core Locations

Divide the days production into equal lots as shown in Table 2360.6-B2a. The Engineer may require additional density lots be established to isolate areas affected by equipment malfunction/breakdown, heavy rain, or other factors that may affect the normal compaction operations. Obtain three cores in each lot. Two cores will be taken from random locations selected by the Engineer. The third core, a companion core, shall be taken within 0.3

TABLE 2360.6-B2A
LOT DETERMINATION

Daily Production		Lots
Metric (ton)	(**English (Ton)**)	
270* – 545	(**300* – 600**)	1
546 – 910	(**601 – 1,000**)	2
911 – 1,455	(**1,001 – 1,600**)	3
1,456 – 3,275	(**1,601 – 3,600**)	4
3,276 – 4,545	(**3,601 – 5,000**)	5
4,546 +	(**5,001 +**)	6

*When mix production is less than 270 metric tons (**300 tons**), establish 1st lot when accumulative tonnage exceeds 270 metric tons (**300 tons**).

meters (**1 foot**) longitudinally from either of the first two cores. The companion cores shall be given to the Department Street Inspector immediately upon completion of coring and sawing. The random locations will be determined by the Engineer using statistically derived stratified random number tables or other approved methods of random number generation. These will also be used for partial lots. Both transverse and longitudinal joints are subject to maximum density requirements. If the random core location falls on an unsupported joint, at the time of compaction, (the edge of the mat being placed does not butt up against another mat, pavement surface, etc.) cut the core with the outer edge of the core barrel 0.3 meters (**1 foot**) away (laterally) from the edge of the top of the mat (joint). If the random core location falls on a confined joint (edge of the mat being placed butts up against another mat, pavement surface, curb and gutter, or fixed face), cut with the outer edge of the core barrel 150 mm ± 12.5 mm (**6 inches ± ½ inch**) from the edge of the top of the mat (ex. center of 100 mm (**4 inch**) core barrel 200 mm ± 12.5 mm (**8 ± ½ inches**) from the edge of the top of the mat). Cores will not be taken within 300 mm (**1 foot**) of any unsupported edge The Contractor shall be responsible for maintenance of traffic, coring, patching the core holes, and sawing the cores if necessary to the proper thickness prior to density testing.

B3 Core Testing

Cores will be taken and tested by the Contractor. Core locations will be determined and marked by the Engineer. The Contractor shall schedule the approximate time of testing during normal project work hours so that the Engineer may observe and record the saturated surface dry and immersed weight of the cores.

Density determination will be made by the end of the next working day after placement and compaction. If multiple layers are

placed in a single day, cores shall be sawn and separated for each layer, tested and reported by the end of the next working day.

The Contractor will cut pavement samples from the completed work with power equipment, and restore the surface by the end of the next working day with new, well compacted mixture without additional compensation. Failure to restore the surface within 24 hours of coring shall subject the Contractor to a fine of $100 per working day, per lot, until the core holes are restored. Cores shall be cut using a 100 mm (**4 inch**) minimum outer diameter coring device. All samples shall be marked with the lot number and core number or letter. The cores shall be transported to the laboratory as soon as possible to prevent damage due to improper handling or exposure to heat. These companion cores may be tested by the Inspector on Department scales or transported to the Department's Field Laboratory or District Materials Laboratory.

Measure each core three times for thickness prior to saw cutting, report the average lift thickness on the core sheet. The average thickness will contribute to thickness compliance as described in Section 2360.7A.

If the Department companion core test result for bulk specific gravity (G_{mb}) deviates beyond the allowable tolerance of 0.030, substitute Department companion result for Contractor's core result and then average the Department result with the non-companion result for the lot density acceptance. If, through analysis of data, it is determined there is a bias in the test results, the Engineer will determine which results are appropriate and shall govern.

If the G_{mb} tolerance fails in more than 2 lots in a day of either consistently high or low differences between the companion cores then an investigation to determine the source of errors shall be conducted. Companion cores samples shall be increased to two per lot and tested until investigation is complete and tolerances are met.

The Engineer may allow recoring of a sample only when the core has been damaged through no fault of the Contractor, either during the coring process or in transit to the laboratory.

B4 Maximum Density Acceptance and Payment Schedule

The density of compacted mixture shall be accepted by pavement cores on a lot basis.

The Contractor's cores will be used for acceptance if the determined bulk specific gravity G_{mb} from AASHTO T-166, Mn/DOT modified or ASTM D1188 is within $\pm$ 0.030 of the state companion G_{mb} value. Payment for lot densities of compacted mixture shall be determined from Table 2360.6-B4 or 2360.6-B4A. Incentive and disincentive payments are for both wearing and non-wearing courses.

When the density requirement has been reduced by one percent, per Table 2360.6-B2, footnote 1 & 2, payment adjustments for lot densities will be made as specified in Table 2360.6-B4A. Incentive payments are excluded when the minimum density has been reduced. However, at the Contractors request and with approval of the Engineer, the reduced density requirement may be waived and density evaluated under Table 2360.6-B4, including incentives, for first lift constructed on aggregate base, reclaimed or cold inplace recycled base courses and first lift of an overlay on a roadway with a 6.35 metric ton (**7 ton**) or less spring load restriction (reduced density shall not be waived for the first lift constructed on PCC pavements). The request and approval shall be made after the first days paving and before the third days paving begins. Once the request has been approved, evaluation of density will be in accordance with Table 2360.6-B2 (excluding footnote 2) and Table 2360.6-B4, and will remain in effect for the duration of mixture placement on that lift. The Contractor will also be responsible for compliance with any construction requirements on subsequent lifts.

TABLE 2360.6-B4
PAYMENT SCHEDULE FOR MAXIMUM DENSITY

Percent of Max Specific Gravity [2] SP Wear (≤100 mm (**4 inches**) from Surface) All MV & LV , SP Shld (4% Void)	Percent of Max Specific Gravity [2] SP Non-Wear (>100 mm (**4 inches**) from Surface) SP Shoulders (3% Void)	% Pay-ment
93.6 and above	94.6 and above	104 [3]
93.1 - 93.5	94.1 - 94.5	102 [3]
92.0 - 93.0	93.0 - 94.0	100
91.0 - 91.9	92.0- 92.9	98
90.5 - 90.9	91.5 - 91.9	95
90.0 - 90.4	91.0 - 91.4	91
89.5 - 89.9	90.5 - 90.9	85
89.0 - 89.4	90.0 - 90.4	70
Less than 89.0 [4]	Less than 90.0	[4]

TABLE 2360.6-B4A [1]
1% REDUCED TABLE

Percent of Max Specific Gravity [2] SP Wear (≤100 mm (**4 inches**) from Surface) All MV & LV , SP Shld (4% Void)	Percent of Max Specific Gravity [2] SP Non-Wear (>100 mm (**4 inches**) from Surface) SP Shoulders (3% Void)	% Pay-ment
91.0 and above	92.0 and above	100
90.0 - 90.9	91.0- 91.9	98
89.7 - 89.9	90.5 - 90.9	95
89.4 - 89.6	90.0 - 90.4	91
89.2 - 89.3	89.5 –89.9	85
89.0 - 89.1	89.0 - 89.4	70
Less than 89.0 [4]	Less than 89.0	[4]

[1] Minimum reduced by one percent for the first lift constructed on aggregate base (mainline and shoulder), reclaimed or cold inplace recycled base courses and first lift of an overlay on a roadway with a 6.35 metric ton (**7 ton**) or less spring load restriction (roadway includes shoulders).

Minimum reduced by one percent on the first lift constructed on PCC pavements (reduced density cannot be waived).

[2] In calculating the percent of maximum specific gravity, report to the nearest tenth.

[3] The payment in this portion of the specification shall apply only if the day's weighted average individual production air voids are within - 0.5 percent of the target air void value. The weighted average air voids shall be based on all the mixture production tests (2360.4e) for the corresponding day and shall be weighted by the tons the corresponding test represents.

[4] The HMA material represented by the lot shall be paid at a 70% pay factor, unless a single core density is less than 87.0% of the maximum specific gravity (Gmm). If a single core density is less than 87.0% of Gmm, the material shall be removed and replaced by the Contractor at their expense with mixture that meets the density requirements; or the Engineer may permit the unacceptable material to remain inplace with a 50% pay factor. The limits of the area to be removed will be determined by additional core samples. These additional core samples shall be taken at the same offset from centerline as the original core; unless the original low density core was taken within 0.45 m (**1 ½ feet**) of an edge of the paver pass. In that case, the additional cores shall be taken 0.45 m

(**1 ½ feet**) from the edge of the paver pass. The densities shall be determined at 15 m (**50 foot**) intervals, both ahead and back of the point of unacceptable core density (less than 87.0% of Gmm), until a point of acceptable core density (87.0% of Gmm or greater) is found. If the incremental core density testing extends into a previously accepted lot, removal of the unacceptable material will be required; however, the results of these tests shall not be used to recalculate the previously accepted lot density. All costs incurred from additional coring and testing, resulting from unacceptable core density, will be paid by the Contractor. The unacceptable pavement area is to be computed as the product of the longitudinal limits so determined by the 15 m (**50 foot**) cores and the full width of the paver pass, laying in the traffic lane or lanes. Shoulders shall be exempt from this calculation unless density failure occurred in the shoulder area.

After the unacceptable material (core density less than 87.0% of Gmm) has been removed and replaced, the density of the replacement material will be determined by the average of two cores. Payment for the replacement material will be in accordance with Tables 2360.6-B4 or 2360.6-B4A, whichever applies. There will be no payment for the material removed. The remainder of the original lot shall have a 70% pay factor.

C Ordinary Compaction Method

Ordinary compaction shall be used for layers identified in the typical sections with a minimum planned thickness of less than 40 mm (**1 ½ inches**), thin lift leveling, wedging layers, patching layers, driveways, areas which cannot be compacted with standard highway construction equipment. Unless otherwise indicated in the Plans or Special Provisions recreational trails shall also be compacted by ordinary compaction. The ordinary compaction method shall not be used on mainline, ramp, or loop paving, unless otherwise designated in the plans or special provisions. When density is evaluated by the ordinary compaction method a control strip shall be used to establish a rolling pattern. This shall be used by the Contractor for the compaction of the asphalt mixture for the layer on which the control strip is constructed, or until a new control strip is constructed. The control strip requirement may be waived by the Engineer in small, localized areas or other areas not conducive to its establishment.

A control strip shall be constructed at the beginning of the work on each lift of each course. Each control strip shall have an area of at

least 330 m^2 (**395 square yards**) and shall be of the same thickness as the lift it represents. The subgrade or pavement course upon which a control strip is to be constructed shall have the prior approval of the Engineer. The control strips shall remain in place and become part of the completed work.

The materials used in the construction of the control strips shall conform to the specified requirements for the course. The materials used in the control strip shall be from the same source and of the same type as the materials used in the remainder of the course that the control strip represents.

The equipment used in the construction of the control strips shall be approved by the Engineer and shall be the same type and mass used on the remainder of the pavement course represented by the control strip. A minimum of two rollers shall be required. A rolling pattern shall be established for each roller. A pneumatic-tired roller shall be available for compaction operations within 24 hours after request by the Engineer. The final rolling shall be performed with a tandem steel-wheeled roller. Areas that are inaccessible to the conventional type rolling equipment shall be compacted to the required density by using trench rollers or mechanical tampers.

Construction of the control strips will be as directed by the Engineer. Compaction shall commence as soon as possible after the mixture has been spread to the desired thickness and shall continue until no appreciable increase in density can be obtained by additional roller's coverages. Densities will be determined by means of a portable nuclear testing device or suitable approved alternate and a growth curve shall be developed to determine the optimum rolling pattern. The Contractor shall furnish documentation of the growth curve to the Engineer.

To determine when no appreciable increase in density can be obtained, two test points shall be established in the control strip on a random basis and the density at each point shall be measured by a portable nuclear device or suitable approved alternate after each roller pass. Rolling shall be suspended when testing shows either a decline of more than 2% of the maximum specific gravity or when additional roller passes fail to increase the density.

After said testing is accomplished, rolling on the remainder of that course shall be done in accordance with the pattern developed in the test strip for that roller. A separate rolling pattern and time interval shall be established for each roller.

A new control strip shall be ordered by the Engineer when:

(a) A change in the JMF is made, or
(b) A change in the source of material is made or a change in the material from the same source is observed.

A new control strip may be ordered by the Engineer or requested by the Contractor when:

(a) Ten days of production have been accepted without construction of a new control strip, or

(b) There are other reasons to believe that a control strip density is not representative of the HMA mixture being placed.

The nuclear testing device shall be furnished and operated by the Contractor. The furnishing of the testing device and the operator will be considered incidental to the furnishing and placement of the HMA mixture and shall not be compensated for separately. The device shall be calibrated according to procedures described in the Mn/DOT Bituminous Manual.

Each course shall be uniformly compacted until there is no further evidence of consolidation and all roller marks are eliminated. When this method is employed, and the quantity of mixture placed by the paver exceeds 100 metric tons (**110 tons**) per hour, at least two rollers are required for compacting the mixture placed by each paver.

C1 Rollers

The following requirements for rollers apply only when compaction is obtained by the ordinary compaction method.

C2 Steel-Wheeled Rollers

Steel-wheeled rollers shall be self-propelled and has a minimum total mass of 7.3 metric tons (**8 tons**), or as otherwise specified in the Contract. When vibratory rollers are used, they shall produce 45 kN/m (**3,085 lbf per foot**) of width. The frequency should be at least 2400 vpm and amplitude setting low. The roller shall be capable of reversing without backlash and shall be equipped with spray attachments for moistening all rollers on both sets of wheels.

C3 Pneumatic-Tired Rollers

The pneumatic-tired roller shall have a compacting width of 1.5 m (**5 feet**) or more. It shall be so constructed that the gross wheel load force shall be a minimum of 13 kN (**3,000 pounds**) per wheel for LV and MV mixtures and SP Level 2-3 mixtures and 22 kN (**5,000 pounds**) per wheel for SP Level 4-6 mixtures and can be varied as directed by the Engineer. The tire arrangement shall be such that full compaction will be obtained over the full width with each pass of the roller.

The roller may be self propelled or provided with suitable tractive equipment, unless otherwise specified in the Contract. If more than one roller is propelled by a single tractive unit, then that combination will be counted as a single roller unit.

C4 Trench Rollers

Trench rollers shall be self propelled and have a mass of not less than 4,400 kg per meter (**2,960 pounds per foot**) of width.

C5 Mixture Temperature Controls

If compaction is obtained by the ordinary compaction method, the minimum laydown temperature in all courses (as measured behind the paver or spreading machine) of the asphalt mixture shall be in accordance with the temperature requirements of Table 2360.6-C5. Unless directed by the Engineer in writing, no paving is allowed under the Ordinary Compaction Method when the air temperature is below 0°C (**32°F**).

TABLE 2360.6-C5
MIXTURE TEMPERATURE CONTROL

Air Temperature	**Compacted Mat Thickness, mm [A]**			
°C (**°F**)	25 mm (**1 inch**)	40 mm (**1 ½ inch**)	50 mm (**2 inch**)	≥75 mm (**3 inch**)
+0-5 (**32-40**)	--	129 [B] (**265**)	124 (**255**)	121 (**250**)
+ 6-10 (**41-50**)	130 [B] (**270**)	127 (**260**)	121 (**250**)	118 (**245**)
+ 11-15 (**51-60**)	127 [B] (**260**)	124 (**255**)	118 (**245**)	115 (**240**)
+ 16-21 (**61-70**)	121 [B] (**250**)	118 (**245**)	115 (**240**)	113 (**235**)
+ 22-27 (**71-80**)	118 (**245**)	115 (**240**)	113 (**235**)	113 (**235**)
+ 28-32 (**81-90**)	113 (**235**)	110 (**230**)	110 (**230**)	110 (**230**)
+ 33 (**91+**)	110 (**230**)	110 (**230**)	110 (**230**)	107 (**225**)

[A] Based on approved or specified compacted lift thickness.

[B] A minimum of one pneumatic-tire roller shall be used for intermediate rolling unless otherwise directed by the Engineer. The Engineer may specify or modify in writing (with concurrence from the Department Bituminous Engineer) a minimum laydown temperature.

2360.7 THICKNESS AND SURFACE SMOOTHNESS REQUIREMENTS

A Thickness

After compaction the thickness of each lift shall be within a tolerance of 6 mm (**¼ inch**) of the thickness shown in the Plans, except that, if automatic grade controls are used, this thickness requirement will not apply to the first lift placed. This thickness requirement will not apply to a leveling lift whether or not automatic grade controls are required. The Engineer may require removal and

replacement, at the Contractor's expense, of any part of any lift that is constructed to less than the minimum required thickness.

Cores taken for density determination shall be measured for thickness also. Each core shall be measured 3 times for thickness prior to sawing. Report the average of these three measurements. Each lot's average core thickness shall be documented and submitted to the Engineer. If the average of the two Contractor cores exceed the specified tolerance, an additional two cores may be taken in the lot in question. The average of all core thickness measurements per day per lift will be used to determine daily compliance with thickness specifications.

On that portion of any lift constructed to more than the maximum permissible thickness, the materials used in the excess mixture above that required to construct that portion of the lift to the Plan thickness plus 6 mm (**¼ inch**) may be excluded from the pay quantities and at the discretion of the Engineer and at the Contractor's expense may be required to be removed and replaced.

B Surface Requirements

After compaction, the finished surface of each lift shall be reasonably free of segregated, open and torn sections, and shall be smooth and true to the grade and cross section shown on the Plans with the following tolerances:

(1) Where a leveling lift is specified, it shall be constructed to within a tolerance of 15 mm (**½ inch**) of the elevations and grades established by the Engineer. This requirement shall also apply to the first lift placed other than leveling when automatic controls are used.

(2) The surface of the final two lifts placed shall show no variation greater than 6 mm (**¼ inch**) from the edge of a 3 m (**10 foot**) straightedge laid parallel to or at right angles to the centerline. Shoulder surfacing and surfacing on temporary connections and bypasses shall show no variations greater than 6 mm (**¼ inch**) from the edge of a 3 m (**10 foot**) straightedge laid parallel to the centerline.

(3) After final compaction, all final lift asphalt wearing surfaces adjacent to concrete pavements shall be slightly higher (but not to exceed 6 mm (**¼ inch**) than the concrete surface. After final compaction, all asphalt surfaces adjacent to gutters, manholes, pavement headers, or other fixed structures shall be slightly higher (but not to exceed 6 mm (**¼ inch**) than the surface of the structure.

(4) Transverse joints (construction joints), at the beginning and end of a project, at paving exceptions, or caused by suspension of daily paving operations, shall show no

variation greater than 6 mm (**¼ inch**) from the edge of a 3 m (**10 foot**) straightedge centered longitudinally across the transverse joint. The Engineer may require correction by diamond grinding when material is placed outside the above described limitations.

(5) The transverse slope of the surface of each lift, exclusive of the shoulder wearing lift, shall not vary from the slope shown in the Plans by more than 0.4 percent.

(6) The distance between the edge of each lift and the established centerline shall be no less than the Plan distance nor more than 75 mm (**3 inches**) greater than the Plan distance. In addition, the edge alignment of the wearing lift on tangent sections and on curve sections of 3 degrees or less shall not deviate from the established alignment by more than 25 mm (**1 inch**) in any 7.5 m (**25 foot**) section.

(7) The finished surface of each lift shall be reasonably free of segregated and open and torn sections.

Any material placed outside the above described limitations shall be removed and replaced after being cut or sawed at no expense to the Department or with the approval of the Engineer, allowed to remain in place at a reduced cost calculated at $12 per square meter (**$10 per square yard**).

C Pavement Smoothness

C1 General

Pavement smoothness will be evaluated on the final mainline pavement surface using a California type profilograph or Inertial Profiler (IP) with a 5 mm (**0.2 inch**) blanking band. Unless otherwise authorized by the Engineer, all smoothness testing shall be performed in the presence of the Engineer. The Engineer and the Contractor shall mutually agree upon scheduling of smoothness testing so that testing can be observed. Any testing performed without the Engineer's presence, unless otherwise authorized, may be ordered retested at the Contractors expense. The following table shows pavement surfaces, which are excluded from profilograph testing, but subject to Section 2360.7B surface requirements.

C1 A Smoothness Requirements

Pavement smoothness requirements will be evaluated by Table 2360.7-C6A, 2360.7-C6B, or 2360.7-C6C. The pavement smoothness table will be identified in the Special Provisions of the proposal.

TABLE 2360.7-C1
PROFILOGRAPH TESTING EXCLUSIONS

Pavement Surfaces Excluded From Profilograph Testing
Ramps, Loops, Climbing Lanes
Side Streets, Side Connections
Turn Lanes, Storage Lanes, Crossovers, Bypass Lanes
Shoulders
Acceleration, Deceleration Lanes
Intersections constructed under traffic – Begin and end the exclusion 30.5 m (**100 feet**) from the intersection radius
Sections less than 15.24 m (**50 feet**) in length
Projects less than 300 m (**1000 feet**) in length
Mainline paving where the normally posted regulatory speed is less than or equal to 70 km/hr (**45 miles per hour**) -- Begin the exclusion at the sign
Single lift overlays over concrete.
Horizontal Curves with a radius less than 289.6 m (**950 feet**). Horizontal Curves with a degree of curvature greater than or equal to 6°. Vertical Curves – Absolute value of grade change is 2 % or more and curve length is 91.4 m (**300 feet**) or less. Vertical Curves – Absolute value of grade change is 3 % or more and curve length is 121.9 m (**400 feet**) or less. Vertical Curves – Absolute value of grade change is 4 % or more and curve length is 182.8 m (**600 feet**) or less. Vertical Curves – Absolute value of grade change is 8 % or more and curve length is 213.4 m (**700 feet**) or less. Note: Begin and end the exclusion at the PC (PVC) and PT (PVT), respectively

C2 Measurement

Smoothness will be measured with a 7.62 m (**25 foot**) California type profilograph or an Inertial Profiler (IP), which produces a profilogram (profile trace of the surface tested). Either type of device must be certified according to the procedure on file in the Bituminous Office. One pass will be made in each lane, 2.74 m (**9 feet**) from centerline. The profilograph or IP shall be in the direction the traffic will be moving. Each lane will be tested and evaluated separately. The Engineer will determine the length in kilometers (**miles**) for each mainline traffic lane. The profilograph will be operated at a speed no greater than a normal walk, no greater than 6 km/hr (**4 miles per hour**). Motive power may be provided manually or by the use of a

propulsion unit approved by the Engineer. The IP will be operated at the optimum speed as defined by the manufacturer.

C3 Profilograph Testing

The Contractor will furnish a properly calibrated, documented, and certified 7.62 m (**25 foot**) California type profilograph or IP. The profilograph or IP shall be equipped with automatic data reduction capabilities unless otherwise authorized by the Engineer. Certification documentation shall be provided to the Engineer on the first day the profilograph or IP is used on the project. User selected profilograph or IP settings are on file in the Bituminous Office. The Contractor will furnish a competent operator, trained in the operation and evaluation of the 7.62 m (**25 foot**) California profilograph or IP.

All objects and foreign material on the pavement surface will be removed by the Contractor prior to testing. The pavement surface will be divided into sections which represent continuous placement. A section will terminate or begin 15.24 m (**50 feet**) before or after a bridge approach panel, bridge surface, manhole or similar interruption. These 15.24 m (**50 foot**) sections, including the transverse joint, will be evaluated under Section 2360.7B, Surface Requirements. A day's work joint will be included in the trace with no special consideration. A section will be separated into segments of 0.1 km (**0.1 mile**). A segment will be in only one traffic lane.

A profilogram will be made for each segment of 15.24 m (**50 feet**) or more. The profilogram will include the 7.62 m (**25 foot**) at the ends of the section only when the Contractor is responsible for the adjoining surface.

End of run areas not included in the profilograph trace and any sections of pavement less than 15.24 m (**50 feet**) in length shall be checked longitudinally with a 3.028 m (**10 foot**) straight edge and the surface shall not deviate from a straight line by more than 6 mm in 3.028 m (**¼ inch in 10 feet**). Transverse joints shall be evaluated by centering the straightedge longitudinally across the transverse joint.

The profile trace and index for each segment of pavement must be furnished to the Engineer within 48 hours after each days run. Identification of all bumps and dips, with signature of the Operator shall be included with the submitted trace.

The Contractor will submit a final evaluation generated from approved software, to the Engineer within five days after all mainline pavement placement. Software is available from the Mn/DOT Bituminous Office website. The evaluation submitted shall be in tabular form, with each 0.1 km (**0.1 mile**) segment occupying a row. Each row shall include the beginning and ending station for the segment, the length of the segment, the profile index for the segment, the profile index incentive/disincentive in dollars for the segment,

and the deductions for bumps in dollars for the segment. Each continuous run will occupy a separate table and each table will have a header that includes the following: the project number, the roadway number or designation, the specified ride table, a lane designation, the mix type of the final lift, the PG binder of the final lift, the date of the profilograph run, and the beginning and ending station of the continuous run. Each table will have a summary at the bottom that includes the following: a subtotal for the profile index incentive/disincentive, a subtotal for the bump deductions, and a total for incentive/disincentive for both profile index and bumps.

The Contractor will be responsible for all traffic control associated with the smoothness testing.

Any portion of the project may be retested if the Engineer determines that the Contractor's test results are in question. If results are found to be inaccurate, the Contractor will be charged at a rate of $155.34 per lane km **($250 per lane mile**) that is retested, with a minimum charge of $500.00. If the results are found to be accurate, the Department will be paying the Contractor at a rate of $155.34 per lane km **($250 per lane mile**) that is retested, with a minimum charge of $500.00.

C4 Profile Index

The profilograph or IP shall be equipped with automatic data reduction capabilities for determining the profile index (PI) unless otherwise authorized by the Engineer. The profilograph trace will be evaluated for the profile index (PI) and bumps in accordance with California Method 526 on file with the Department Bituminous Engineer. The original trace shall be provided to the Engineer.

A profile index shall be calculated for each segment. If an IP is used the corresponding International Roughness Index (IRI) for each segment shall be submitted to the Bituminous Office. The index will be determined by summing the vertical deviations outside either a 5 mm (**0.2 inch**) blanking band or outside a zero blanking band depending on the number of lifts in the construction. The units of this index are mm per km (**inch per mile**). When there is a segment of 76.2 m (**250 feet**) or less in length, the profilograph or IP measurements for that segment shall be added to and included in the evaluation of the adjacent section to that segment.

Bumps and dips equal to or exceeding 10.2 mm in a 7.62 m (**0.4 inch in a 25 foot**) span shall be identified separately. When the profile trace shows a successive, uninterrupted bump, dip; or dip, bump combination (up to a maximum of 3 alternating trace deviations that relate to one bump or dip on the roadway), identify and evaluate these occurrences as one event.

C5 Surface Correction

All areas represented by deviations of 28 mm (**1.1 inch**) or more, as measured by the 7.62 m (**25 foot**) profilograph or IP, will be corrected by the Contractor.

The Contractor may elect to correct pavement segments having no more than two events or two individual bumps or dips with a vertical deviation of 10.2 to 25 mm (**0.4 to 1.0 inch**) in a 7.62 m (**25 foot**) span. Correction of segments with more than two events or two individual bumps or dips, as defined above, will be allowed only when approved by the Engineer. The Contractor will be assessed a penalty for dips or bumps of 10.2 to 25 mm (**0.4 to 1.0 inch**) that are not corrected. Bumps and dips not corrected will also be included in the evaluation for the segment smoothness. Corrected dips or bumps will be considered satisfactory when the profilogram shows the dips or bumps are less than 10.2 mm in a 7.62 m (**0.4 inch in a 25 foot**) span.

Bump, dip, and smoothness correction work shall be for the entire traffic lane width. Pavement cross slope shall be maintained through corrective areas.

Corrective work shall be made by diamond grinding unless other methods are approved by the Engineer. Other methods may include; overlaying the area, or replacing the area by milling and inlaying. Any corrective actions by milling and inlay or overlay shall meet the specifications for ride quality over the entire length of the correction, including the first and last 15 m (**50 feet**). Bumps or dips in excess of 10.2 mm (**0.4 inches)** at transverse joints at areas of corrective actions utilizing overlay or milling and inlay, shall be removed by diamond grinding. The Contractor shall notify the Engineer prior to commencement of the corrective action. If the surface is corrected by overlay, inlay or replacement, the surface correction shall begin and end with a transverse saw cut.

If the smoothness evaluation indicates that corrective work is necessary for more than 50% of a segment, surface correction will be limited to mill and inlay (40 mm (**1 ½ inch**) min).

All corrective work shall be subject to the approval of the Engineer. After all required correction work is completed, a final profile index shall be determined. Corrective work and re-evaluation will be at the Contractor's expense.

C6 Payment

The cost of certified smoothness testing and associated traffic control will be incidental to the cost of the Wear Course Mixture.

The Contractor may receive an incentive payment or be assessed a penalty based on the number of segments and the initial profile index. The total ride incentive shall not exceed 10% of the total mix price for pavement smoothness evaluated under Table 2360.7-C6A, 5% of the total mix price for pavement smoothness evaluated under Table 2360.7-C6B, or 5% of the total mix price for pavement smoothness evaluated under Table 2360.7-C6C. The maximum allowable net incentive (total incentive minus disincentive) payment shall be calculated by multiplying the total tons paved by the mixture price by the appropriate incentive cap. Pay adjustments for incentives will only be based on the initial Profile Index before any corrective work has been performed. Pavement that contains corrective action for profile or bumps is not eligible for incentive pay. These payments or assessments will be based on the following schedules.

The Contractor will not receive a net incentive payment for ride if more than 25% of all density lots for the project fail to meet minimum density requirements.

For each traffic lane, a penalty will be assessed for each bump or dip of 10.2 to 25 mm (**0.4 to 1.0 inch**) that is not corrected. Penalties, based on the table the profile index is evaluated under, are as follows:

Table 2360.7-C6A:	$900
Table 2360.7-C6B:	$675
Table 2360.7-C6C:	$450

Bumps or dips resulting from a construction joint will be assessed a $900 penalty, regardless of the table used for evaluation of pavement smoothness.

The Engineer may, at his discretion, assess a penalty in lieu of requiring the Contractor to take corrective action when the profile index for a segment indicates corrective action is necessary.

Penalties, based on the table the profile index is evaluated under, are as follows:

Table 2360.7-C6A:	$560 per 0.1 km (**$900 per 0.1 mile**)
Table 2360.7-C6B:	$420 per 0.1 km (**$675 per 0.1 mile**)
Table 2360.7-C6C:	$280 per 0.1 km (**$450 per 0.1 mile**)

TABLE 2360.7-C6A *
INITIAL PROFILE INDEX FOR 5MM (0.2 INCH) BLANKING BAND

mm per km per 0.1 km segment	**(Inches per mile) (per 0.1 mile segment)**	**Dollars per Segment (Metric)**	**Dollars per Segment (English)**
0- 13.4	(**0.0 – 0.8**)	210	(**335**)
13.5 – 25.3	(**0.9 - 1.6**)	145	(**225**)
25.4 – 38.7	(**1.7 - 2.4**)	80	(**115**)
38.8 – 78.9	(**2.5 - 5.0**)	0	(**0**)
79.0 – 92.3	(**5.1 - 5.8**)	(80)	((**115**))
92.4 - 105.7	(**5.9 - 6.7**)	(145)	((**225**))
105.8 - 118.3	(**6.8 - 7.5**)	(210)	((**335**))
Over 118.3	(**Over 7.5**)	Corrective Action	Corrective Action

***** Typically, 3-lift minimum construction

TABLE 2360.7-C6B *
INITIAL PROFILE INDEX FOR 5MM (0.2 INCH) BLANKING BAND

mm per km **per 0.1 km segment**	(**Inches per mile**) **(per 0.1 mile segment)**	**Dollars per Segment (Metric)**	**Dollars per Segment (English)**
0 - 15.8	(**0.0 - 1.0**)	145	(**225**)
15.9 - 31.6	(**1.1 - 2.0**)	100	(**150**)
31.7 - 47.3	(**2.1 - 3.0**)	55	(**75**)
47.4 - 110.5	(**3.1 - 7.0**)	0	(**0**)
110.6 - 126.3	(**7.1 - 8.0**)	(55)	((**75**))
126.4 - 142.0	(**8.1 - 9.0**)	(100)	((**150**))
142.1 - 157.8	(**9.1- 10.0**)	(145)	((**225**))
Over 157.8	(**Over 10.0**)	Corrective Action	**Corrective Action**

***** Typically, 2-lift construction

TABLE 2360.7-C6C *
INITIAL PROFILE INDEX FOR 5MM (0.2 INCH) BLANKING BAND

mm per km **per 0.1 km segment**	(**Inches per mile**) **(per 0.1 mile segment)**	**Dollars per Segment (Metric)**	**Dollars per Segment (English)**
0 - 31.6	(**0.0 - 2.0**)	95	(**150**)
31.7 - 47.4	(**2.1 - 3.0**)	65	(**100**)
47.5 - 79.0	(**3.1 - 5.0**)	35	(**50**)
79.1 - 158.0	(**5.1 - 10.0**)	0	(**0**)
158.1 - 189.6	(**10.1 - 12.0**)	(35)	(**(50)**)
189.7 - 221.2	(**12.1 - 14.0**)	(65)	(**(100)**)
221.3 - 252.8	(**14.1-16.0**)	(95)	(**(150)**)
Over (252.8)	(**Over 16.0**)	Corrective Action	**Corrective Action**

*Typically, single lift construction

2360.8 METHOD OF MEASUREMENT

A Asphalt Mixture

Asphalt mixture of each type will be measured separately by mass, based on the total quantity of material hauled from the mixing plant, with no deductions being made for the asphalt materials.

B Blank

C Asphalt Mixtures Measured by the Square Meter (Square Yard) per Specified (mm (inch)) and for Mixtures Measured by the (Square Yard inch)

Asphalt mixture of each type and for each specific lift will be measured separately by area and by thickness on the basis of actual final dimensions placed. The constructed thickness shall meet tolerances set forth in Sections 2360.7A.

2360.9 BASIS OF PAYMENT

Payment for the accepted quantities of asphalt mixture used in each course at the Contract prices per unit of material shall be compensation in full for all costs of constructing the asphalt surfacing as specified, including the costs of furnishing and incorporating any asphalt binder, mineral filler, hydrated lime, or anti-stripping additives that may be permitted or required.

If the production lab density at the design gyrations at the recommended or established asphalt content is in excess of 2565 kg/m^3 (**160 pounds per cubic foot**), payment for mixture will be calculated at the following percent of the Contracted unit price.

% Payment = {100 - ({100 x (production density at design gyrations - 2565)} / 2565)}

% Payment = {100 - ({100 x (production density at design gyrations - 160)} / 160)} ENGLISH

In the absence of Contract items covering shoulder surfacing and other special construction, the accepted quantities of material used for these purposes will be included for payment with the wearing course materials.

The Contractor is responsible to complete yield checks and monitor thickness determinations so that the constructed dimensions correspond with the required Plan dimensions throughout the entire length of the Project. The tolerances for lift thickness shown in 2360.7A and B, Thickness and Surface Smoothness Requirement is for occasional variations and not for continuous over-running or under-running, unless ordered or Authorized by the Engineer.

Payment for the item of asphalt mixture production at the Contract unit price of mixture produced shall be compensation in full for all costs of producing the mixture and loading it on board the Department's trucks at the mixing plant. The provisions of Mn/DOT 1903 are modified to the extent that the Department will not make a price adjustment in the event of increased or decreased quantities of asphalt mixture items. Payment for plant mixed asphalt surface will be made on the basis of the following schedule:

Item No.	**Item**	**Unit**
2350.501	Type (1) (2) Wearing Course Mixture ((4))	metric ton (**ton**)
2350.502	Type (1)(2) Non Wearing Course Mixture ((4))	metric ton (**ton**)
2350.503	Type (1)(2)(3) Course Mixture ((4)), (5) mm (**inch**) thick	square meter (**square yard**)
2350.504	Type (1)(2)(3) Course Mixture ((4))	(**square yard inch**)
2350.505	Type (1)(2) Bituminous Mixture for Specified Purpose	metric ton (**ton**)
2350.506	Type (1)(2) Bituminous Mixture Production	metric ton (**ton**)
2360.501	Type(1) (6) Wearing Course Mixture ((8),(4))	metric ton (**ton**)
2360.502	Type (1) (6) Non Wearing Course Mixture ((8),(4))	metric ton (**ton**)

2360.503 Type (1) (6) (7) Course Mixture ((8),(4))
(5) mm (**inch**) thick .....square meter (**square yard**)
2360.504 Type (1) (6) (7) Course Mixture ((8),(4))
.....(**square yard inch**)
2360.505 Type (1) (6) Bituminous Mixture for
Specified Purpose .....metric ton (**ton**)
2360.506 Type (1) (6) Bituminous Mixture Production
.....metric ton (**ton**)

(1) Mixture Design Type (LV, MV, SP or SM as appropriate).
(2) Aggregate size designation, as per Table 2360.2-E.
(3) "Wearing" or "Non Wearing" as appropriate.
(4) AC binder grade designation.
(5) Specified lift thickness.
(6) Aggregate Size Designation, 9.5, 12.5 or 19 as appropriate.
(7) "Wearing" or "Non Wearing" as appropriate.
(8) Traffic Level as per Table 2360-1-A.