OKLAHOMA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISIONS
FOR
QUALITY CONTROL AND ACCEPTANCE PROCEDURES FOR
PORTLAND CEMENT CONCRETE PAVEMENTS

These Special Provisions revise, amend, and where in conflict, supersede applicable sections of the 1999 Standard Specifications for Highway Construction, English and Metric. Units of measurement are provided in the subsections in both English and Metric equivalents. The units for this project shall be those specified in the project plans. These Special Provisions apply to Portland Cement Concrete pavements.

414.01. Description. *(Add the following.)*

Contractor's quality Control and acceptance procedures will apply to all Class A concrete and related reinforcing steel used in pavement.

414.04. Construction methods. (*Amend to include the following:)*

(l) **Contractor's Quality Control Testing and Inspection.** The contractor shall provide quality control personnel as necessary to assure the production of quality products as specified. Such personnel shall include one or more quality control technicians who either individually or collectively are fully qualified in the production, placement and testing of concrete and reinforcing steel placed in portland cement concrete pavement. Sampling and/or testing of Construction materials for either control or acceptance purposes shall be accomplished by persons certified in the appropriate area(s) by the Oklahoma Highway Construction Materials Technician Certification Board. The Contractor shall be responsible for the formulation of all mix designs. This may be accomplished by qualified Contractor personnel or subcontractor, such as approved independent laboratories. Mix designs and changes to the mix designs shall be subject to review by the Engineer. The Contractor shall perform or have performed all field sampling and testing necessary to ensure that materials and products are within the specified acceptable range. Copies of the Contractor's quality control tests shall be provided to the Engineer within 24 hours or at time intervals acceptable to the Engineer. Certifications by the manufacturers may be used in lieu of field test when such tests in the field are impracticable. Portland cement and additives are examples of materials in this category.

(1) *Contractor's Process Control*. The Contractor shall be responsible for the process control of all materials during handling, blending, mixing and placing operations to produce acceptable concrete pavement. At no time will the Engineer issue instructions to the Contractor or producer as to setting of dials, gauges, scales and meters. However, he/she may advise the Contractor against the continuance of any operations or sequence of operations which will result in noncompliance with specification requirements.

(2) *Contractor's Testing.* For slump, unit weight, and the three characteristics subject to pay adjustments in these special provisions, the Contractor sampling and testing, as a minimum, shall comply with the schedule in the Subsection (m)(12), "Contractor's Testing and Engineer's Acceptance Procedures." Additional sampling and testing to ensure compliance with standard specifications and other special provision requirements shall be in accordance with the Contractor's quality control plan.

(3) *Contractor's Laboratory.* The Contractor shall provide a fully equipped laboratory at a location no more than 50 road miles from the production site. The laboratory shall be subject to the approval of the Engineer.

(4) *Contractor's Quality Control Plan.* Prior to initiation of work, the Contractor shall prepare plan to ensure that acceptable quality can and will be obtained. The plan, which is to be submitted to the Engineer at least one week prior to the prework conference, shall comply with S.P. 643-6QA and cover all of the items discussed in Sections 414 and 701 of the Standard Specifications. However, the Contractor must tailor the plan to meet the specific needs of the project. The Contractor shall supplement or delete from the list as necessary to accomplish this end. Once accepted by the Engineer, the plan becomes a part of the contract and shall be enforced accordingly. Subsequent changes to the plan may be required by the

Engineer in order to adjust to changes in the process or to correct problems in meeting specification requirements.

(5) *Identifying Testing Precision and Bias.* For each test characteristic of each contract item for which control charting is required, the following initialization procedure shall be performed:

5.1 Initial testing shall be performed to identify any testing biases between the Contractor's and the Department's testing equipment and procedures. This testing will be referred to as "initialization" testing and will include the plant startup testing as well as the first lot for each contract item for which control charting is required. In all instances, technician- and equipment-identification numbers shall be recorded with each test result to assist in troubleshooting potential testing discrepancies.

5.2 The frequency of testing for initialization lots shall be double the normally-specified testing frequency. As such, initialization lots shall be broken down into twelve (12) equal sublots with the sampling within each sublot to be performed at a random location or time interval in accordance with ASTM D 3665 or other acceptable means for ensuring random sampling of the materials. Optionally, the Engineer and Contractor can agree to use the 12 test results from two lots rather than doubling the sublots where 12 test results for one lot is specified for initialization comparisons.

5.3 During the initialization testing, for each sublot, the Contractor shall obtain gradation samples for coarse and fine aggregate in accordance with AASHTO T 2 under direct observation by the Engineer. The Contractor shall split each sample in accordance with AASHTO T 248. The Contractor and the Department shall each perform one (1) set of gradation sieve analyses on the split samples in accordance with AASHTO T 27.

5.4 During the initialization testing, for each sublot, fresh concrete samples shall be obtained simultaneously by the Contractor and the Engineer from the same batch and the same proximity within the batch. For each sublot, the Contractor and the Department shall each perform the following tests (all from the same batch of concrete): one (1) slump test; one (1) unit weight test; one (1) air-content test; cast six (6) cylinder specimens. The duplicate tests for slump, unit weight, and air content shall be recorded according to the order performed. Three (3) cylinder specimens each shall be tested for compressive strength at 7-days and three (3) each at 28-days.

5.5 During initialization testing, the Contractor and the Engineer shall not divulge their respective test results until the conclusion of all sampling and associated testing for a given lot and quality characteristic.

5.6 At the conclusion of the sampling and associated testing for a given initialization lot and quality characteristic, a statistical "paired-t test" will be performed by the Engineer (in accordance with the Department's Construction Control Directive on *Use of Contractor's Test Results for Acceptance Purposes*) using the pairs of initialization test data . The Engineer may, at his discretion, exclude from this and subsequent analyses any initialization test data that are clearly due to explainable special-cause variation provided the cause of said variation has been corrected so as to be unlikely to reoccur.

5.7 For those characteristics showing a *statistically*– and *practically*– significant bias between the Contractor's and the Department's test methods, the following shall govern:

5.7.1 The Department's test results shall be relied upon for acceptance and pay adjustment until such time as:

5.7.1.1 the source of the bias has been identified and eliminated and the lack of bias subsequently validated in accordance with the Department's Construction Control Directive on *Use of Contractor's Test Results for Acceptance Purposes*, or

5.7.1.2 as provided in Subsection 5.7.2 below.

5.7.2 The Contractor may request evaluation of the testing bias via side-by-side

three-way testing with an independent-assurance laboratory. In this instance, the following shall govern:

5.7.2.1 The Department will select the independent-assurance laboratory, which may be the Department's own independent-assurance laboratory or a third-party laboratory of the Department's choosing.

5.7.2.2 The steps outlined in Subsection 5.2. through 5.5. shall be performed utilizing three-way split samples, with the Contractor, Department, and independent-assurance laboratory each performing tests on the split-sample specimens.

5.7.2.3 At the conclusion of the three-way split-sample testing, three statistical "paired-t tests" will be performed by the Engineer (in accordance with the Department's Construction Control Directive on *Use of Contractor's Test Results for Acceptance Purposes*) using the three pairs of evaluation test data (e.g. Contractor's versus Department's, Contractor's versus independent-assurance laboratory's, and Department's versus independent-assurance laboratory's test results).

5.7.2.4 If either of the following conditions are identified as a result of a three way split-sample testing and analysis, Subsection 5.7.2.6 shall govern, otherwise subsection 5.7.2.5 shall govern :

(i) There is a *statistically*- **and** *practically*-significant bias between the Contractor's test methods and the independent-assurance laboratory's test methods, or

(ii) the test methods employed by the Contractor during three way split-sample testing are not representative of the test methods to be employed by the Contractor during the normal execution of the project.

5.7.2.5 The following shall govern subject to Subsection 5.7.2.4:

(i) The Contractor shall not be held responsible for any additional costs incurred by the Department in conjunction with the three-way split-sample testing.

(ii) The Contractor's test results shall be relied upon for acceptance and pay adjustment subject to the provisions of Subsection 5.8.

5.7.2.6 The following shall govern subject to Subsection 5.7.2.4:

(i) The Contractor shall reimburse the Department for all additional costs incurred by the Department as a result of the three-way split-sample testing.

(ii) The Department's test results shall be relied upon for acceptance and pay adjustment in accordance with Subsection 5.7.1.1.

5.8 **For those characteristics where the statistical paired-t test validates the Contractor's test methods, the Contractor's test results will be used for acceptance and pay adjustment subject to the following:**

5.8.1 The Engineer will perform ongoing paired testing at the approximate frequency of one (1) paired test per lot, but not less than one (1) paired test for every ten (10) sublots.

5.8.2 The Engineer will keep and maintain testing-bias control charts in accordance with the Appendix A, *"Use of Contractor's Test Results for Acceptance Purposes."*

5.8.3 In the event the Engineer's testing-bias control charts demonstrate an out-of-control condition for testing bias, the following procedures shall be followed:

5.8.3.1 The Contractor and Engineer shall immediately investigate the

probable cause.

5.8.3.2 If the probable cause is identified and corrected or if the resulting bias is (according to the judgment of the Engineer) not likely to exceed the limits for Allowable Systemic Testing Bias (ASTB) set forth in Appendix A, *"Use of Contractor's Test Results for Acceptance Purposes."*

(i) Acceptance and pay adjustments for that quality characteristic will continue to be based on the Contractor's test results.

(ii) At the Engineer's discretion, the errant test results may be discarded from the acceptance and pay-adjustment calculations. If replacement test results are available (i.e. Department tests were performed on the same sublots as the discarded Contractor test results) the Department's test results may, at the Engineer's discretion, be substituted for the discarded test results.

5.8.3.3 If the probable cause is not corrected and the resulting bias is (according to the judgment of the Engineer) likely to exceed the limits for Allowable Systemic Testing Bias (ASB.) set forth in the Department's Construction Control Directive on *Use of Contractor's Test Results for Acceptance Purposes*,

(i) All subsequent testing for that quality characteristic will be paired testing until such time as the source of the unacceptable testing bias is clearly identified and corrected and the validity of the Contractor's test methods has been re-established.

(ii) During this period of 100% paired testing, acceptance and pay adjustments for that quality characteristic will be based on the Department's test results rather than the Contractor's.

(6) *Control Charts for Quality Control.* The Contractor shall maintain and keep current control charts covering, as a minimum, the characteristics of slump, unit weight, air content, gradation (for each sieve), and strength. In all instances, technician- and equipment-identification numbers shall be recorded with each test to assist in troubleshooting potential testing discrepancies.

6.1 The control charts shall be "individuals" or "individuals and moving range" (I&MR) type control charts or as otherwise approved by the Engineer.

6.2 The charts shall identify the project number; the contract item number; the characteristic being measured; the date, time, lot #, sublot #, technician identification # and equipment identification # for each measurement; the applicable upper and lower control limits (but NOT the specification limits); the Contractor's test results; and any other data needed to facilitate control of the process and identify out-of-control conditions for the process in a timely manner.

6.3 The centerline, standard deviation, and upper and lower control limits for each control chart shall initially be calculated based on the initialization test results for each characteristic and contract item, excluding any initialization test results clearly due to explainable special-cause variation. Written approval by the Engineer will be required prior to any such exclusion of test data.

6.4 An "out of control" condition is defined as the condition resulting from any one of the following eight (8) "alarm" conditions occurring on a single control chart:

6.4.1 Any one point is more than 3 standard deviations from the centerline.

6.4.2 Nine points in a row are on the same side of the centerline.

6.4.3 Six points in a row are all increasing or all decreasing.

6.4.4 Fourteen points in a row are alternating up and down

6.4.5 Two out of three points are more than 2 standard deviations from the centerline (and on the same side of the centerline).
6.4.6 Four out of five points are more than 1 standard deviation from the centerline (and on the same side of the centerline).
6.4.7 Fifteen points in a row are all within 1 standard deviation of the centerline.
6.4.8 Eight points in a row are all more than 1 standard deviation from the centerline (on either side of the centerline).

6.5 Whenever an out-of-control condition corresponding to alarm criteria 6.4.1, 2, 3, 5, 6 or 8 is observed for any of the control charts, the Contractor shall provide written notification to the Engineer concerning said out-of-control condition within 18 hours of the time the alarm-generating test was performed. In addition, the Contractor shall provide written notification to the Engineer (within 36 hours of the time the alarm-generating test was performed) concerning the investigative and/or corrective actions taken or to be taken. **Failure to provide written notification to the Engineer within the time periods specified shall result in an automatic one-half-percent reduction in the composite pay factor for the affected lot for each failure to comply with the specified notification procedures.** After the probable-cause investigation for the out-of-control condition has been completed, written notification shall be provided to the Engineer stating the probable cause and corrective actions taken or to be taken to reduce the likelihood of reoccurrence (or, stating that the probable cause could not be determined, if such is the case). The Engineer may, at his discretion, exclude from pay-adjustment calculations any out-of-control test data for which the special-cause variation has been adequately identified and explained, provided the cause of said variation has been corrected so as to be unlikely to reoccur. (NOTE: Not all out-of-control conditions will require corrective action. For example, a steady drift in strength values due to temperature-induced changes in water demand may not require corrective action if the strengths being obtained remain above specified levels. However, all out-of-control conditions shall be investigated for probable cause, regardless of the proximity of the measured values to the specification limits.)

6.6 In the event a significant systemic change to the process occurs or is observed (e.g. change in raw material sources, change in mix proportions, steady drift in compressive strength, etc.), the control limits (including centerline and standard deviation) for the affected characteristics shall be recalculated using the available test data that best represent the new process. Any such changes to control limits must be approved in writing by the Engineer.

(m) **Acceptance.** While the Contractor shall be fully and exclusively responsible for producing an acceptable products, acceptance responsibility rests with the Engineer. The entire lot of Portland cement concrete as defined in Subsection (m)(11) will be accepted or rejected and paid for on the basis of acceptance test results.

(1) *Basis of Acceptance and Payment.* The following characteristics will be considered when determining the acceptability and pay factors for Portland cement concrete pavement. However, all of the requirements of the Standard Specifications on materials and workmanship except those superseded by special provisions in this contract, shall remain in effect.

(a) Gradation
(b) Air Content
(c) Strength

Several methods are available to test for characteristics (a), (b) and (c). While only one method will be used, several tests may be made to measure these characteristics. The pay factors that relate to the gradation will be considered in a group with only the lowest pay factor for the individual sieves to be considered in determining payment while all of the sieves specified in sections 701.05(e) and 701.06(c) of the Standard Specifications or as modified by other Special Provisions or plan notes in this contract shall be run, only the

percentage passing the No. 200 sieves for both coarse and fine aggregate will be included in the Percent-within-Limits pay-factor calculations. However, the standard acceptance requirements for all sieves will remain in force as specified in sections 705.01 and 705.06. The remaining pay factors will be considered individually in determining payment.

(2) *Criteria for Lot Acceptance and Payment.* Except for thickness and surface smoothness, conformance with the specifications will be judged on the basis of the following three criteria:

2.1 The estimated Percent-within-Limits (*PWL*) with respect to gradation, air content and strength. The *PWL* with respect to a particular quality characteristic is the amount of the materials and construction which falls within the specified limit(s) in the following tables:

Quality Characteristic	**Lower Specification Limit (LSL)**	**Upper Specification Limit (USL)**
Gradation:		
Sieve # 200 (Coarse)	No Lower Limit	2.0 %
Sieve # 200 (Fine)	No Lower Limit	3.0 %
Air Content	4.5%	7.5%
28-Day Strength (Class A)	3,800 psi	No Upper Limit
28-Day Strength (Class AP)	3,000 psi	No Upper Limit

Quality Characteristic	**Lower Target Limit (LTL)**	**Upper Target Limit (UTL)**
Gradation:		
Sieve # 200 (Coarse)	No Lower Limit	1.0 %
Sieve # 200 (Fine)	No Lower Limit	1.0 %
Air Content	5.5%	6.5%
28-Day Strength (Class A)	4,200 psi	No Upper Limit
28-Day Strength (Class AP)	3,750 psi	No Upper Limit

2.2 For the characteristic of strength, whenever any individual test result as defined in Subsection (m)(12) falls below the corresponding lower critical limit (LCL) listed in the following table, acceptance of the lot will be based on the amount of materials and construction which falls below that critical limit.

Characteristic	**Lower Critical Limit (LCL)**
Strength (Class A)	3,000 psi
Strength (Class AP)	2,500 psi

2.3 Any load of concrete that is visually unacceptable or reasons of being too wet, excessively segregated, or otherwise obviously deficient will be rejected for use in the work. Furthermore, sections of completed pavement which from visual observation or known deficiencies appear to be seriously inadequate will be extensively tested. The results of such tests will not be used for pay adjustment purposes, but will be used to determine whether the section is totally unacceptable and must be removed. In the event that a section is determined to be unacceptable, its removal and replacement shall be at no additional cost to the Department.

(3) *Acceptable and Rejectable Quality Levels.* A lot shall be considered of acceptable quality with respect to a particular characteristic if the *PWL*, as defined in Subsection (2), is no less than 90 percent. In addition, no individual test result on the strength of an acceptable-quality-level lot shall fall below the critical limits defined in Subsection (m)(2). A lot shall be considered of rejectable quality with respect to a particular characteristic if the *PWL*, as

defined in Subsection (m)(2), is less than 50 percent. Lots exceeding the Acceptable Quality Level shall be subject to positive pay adjustments as defined in Subsection (m)(5.1.2). Lots failing to achieve the Acceptable Quality Level but exceeding the Rejectable Quality Level shall be subject to negative pay adjustments as defined in Subsection (m)(5.1.2). Lots failing to achieve the Rejectable Quality Level shall be subject to removal and replacement or zero pay (at the discretion of the Engineer.)

(4) *Determination of Percent-within-Limits (PWL)*. The *PWL* with respect to each of the characteristics of gradation, air content and strength will be determined as follows:

4.1 Compute the sample mean ($\overline{X}$) and the sample standard deviation (S`) as follows, where N = the number of individual test results (i.e. the number of Xi's):

$$\overline{X} = \frac{\sum X_i}{N} \qquad S' = \sqrt{\frac{\sum_{i=1}^{N} (X_i - \overline{X})^2}{N - 1}}$$

4.2 For a two-sided specification:

4.2.1 If $\overline{X}$ falls outside the target limits (LTL and UTL) and inside the specification limits (LSL and USL), compute the target-adjusted standard deviation (S'') as follows:

$$S'' = \sqrt{S'^2 + (X_{target} - \overline{X})^2}$$

where X_{target} = the nearest target limit (LTL or UTL)

4.2.2 If $\overline{X}$ falls inside the target limits (LTL and UTL) or outside the specification limits (LSL and USL), compute the target-adjusted standard deviation (S'') as follows:

$$S'' = S'$$

4.3 For a one-sided specification:

4.3.1 If $\overline{X}$ falls between the specification limit and the target limit, compute the target-adjusted standard deviation (S'') as follows:

where X_{target} = the nearest target limit (LTL or UTL) $S'' = \sqrt{S'^2 + (X_{target} - \overline{X})^2}$

4.3.2 If $\overline{X}$ does not fall between the specification limit and the target limit, compute the target-adjusted standard deviation (S'') as follows:

$$S'' = S'$$

4.4 Using the target-adjusted standard deviation (S''), compute the upper quality index

(Q_u) and/or the lower quality index (Q_L) corresponding to the upper and/or lower specification limits listed in Subsection (m)(2):

$$Q_U = \frac{USL - \overline{X}}{S''} \qquad Q_L = \frac{\overline{X} - LSL}{S''}$$

4.5 Using Table 1 (for sample size N = 6 or the appropriate table for other values of N), determine the percentage of materials and construction falling outside the specification limits PD_U and/or PD_L associated with Q_U and/or Q_L, respectively. Add these two values to obtain the lot percent defective (*PD*):

$$PD = PD_U + PD_L$$

4.6 Determine the percentage of materials and construction falling within the specification limits *PWL* as follows:

$$PWL = 100 - PD$$

4.7 In the event that an individual test result on strength falls below the corresponding lower critical limit (*LCL*) listed in Subsection (m)(2), compute the lower critical quality index (Q_{LC}):

$$Q_{LC} = \frac{\overline{X} - LCL}{S''}$$

4.8 Where all terms are as previously defined. The quality of Q_{LC} is then used in Table 1 to determine the percentage of materials and construction falling below the lower critical limit (PD_{LC}).

(5) *Pay Factors for Lot Quality Characteristics.* Except for pavement smoothness and thickness, the pay factor (*PF*) for each quality characteristic will be determined as follows:

5.1 **Case-I:** Provided that no individual test result on strength falls below the corresponding lower critical limit (*LCL*) listed in Subsection (m)(2), the pay factor (*PF*) for each of the characteristics of strength, air content, and for each of the sieves listed in Subsection (m)(1) will be determined as follows:

5.1.1 Compute the Percent-within-Limits (*PWL*) as described in Subsection (m)(4).

5.1.2 If *PWL* is greater than or equal to 50 percent, compute the pay factor (*PF*) using the equation:

$$PF = 3.24(PWL) - 0.016(PWL)^2 - 62$$

5.1.3 If *PWL* is less than 50 percent, the Engineer may require removal and replacement of the defective lot at the Contractor's expense. If this option

is not exercised, the Contractor may elect to replace the lot or leave it in place subject to a pay factor (for that quality characteristic) of *PF = 0%.*

5.2 **Case II:** In the event that an individual test result on strength falls below the corresponding critical limits in Subsection (m)(2), the lot will be re-evaluated for the deficient characteristic by taking cores. Coring shall be performed as directed by the Engineer. The *PWL* will be computed twice: once based solely upon the original test results and once based solely upon the core results. The final disposition of the lot will be based on the minimum of the two *PWL* values.

When the lot is re-evaluated for concrete strength, the sampling rate shall be at least two cores per sublot, with the first location within the sublot selected at random and the additional core(s) within a given sublot taken within 5-feet of the first. The cores within a sublot shall be averaged and considered as one individual test result.

The pay factor for strength will be determined based on the core test results as follows:

5.2.1 Compute the percentage of materials and construction falling below the lower critical limit (PD_{LC}) as described in Subsection (m)(4).
5.2.2 If PD_{LC} is less than or equal to5 percent, proceed to step 4.
5.2.3 If PD_{LC} is greater than 5 percent, the defective lot shall be removed and replaced at no cost to the Department.
5.2.4 Using the core test results, compute the Percent-within-Limits (PWL_{core}) as described in Subsection (m)(4).
5.2.5 Using the original test results, compute the Percent-within-Limits ($PWL_{original}$) as described in Subsection (m)(4).
5.2.6 The final *PWL* for the lot shall be the value calculated from the cores.
5.2.7 If *PWL* is greater than or equal to 50 percent, compute the pay factor (*PF*) using the equation:

$$PF = 3.24(PWL) - 0.016(PWL)^2 - 62$$

5.2.8 If *PWL* is less than 50 percent, the Engineer may require removal and replacement of the defective lot at the Contractor's expense. If this option is not exercised, the Contractor may elect to replace the lot or leave it in place subject to a pay factor of *PF = 0%.*

(6) *Pay Adjustment For Lots.* Once a lot has been defined, its identity will be maintained throughout the mixing and placement process. When the lot is completed, the individual pay factors determined in Subsection (m)(5) for gradation, air content and strength will be used to calculate a composite pay factor (*CPF*) and a pay adjustment (*PA*) for the subject lot as follows:

$$CPF = \frac{6S + 3AC + G}{10} \qquad PA = (CPF - 1)(CUP)(Q_1)$$

Where:
CPF = composite pay factor
S = pay factor for strength
G = lowest pay factor for gradation
AC = pay factor for air content

PA = pay adjustment for the lot
CUP = contract unit price ($/Yd^2 ($/m^2))
Q1 = quantity of concrete in the lot (Yd2 (m^2))

(7) *Smoothness Acceptance and Pay Adjustment.* For smoothness determination and pay adjustment purposes, the pavement surface will be tested on an extent-to-extent basis in accordance with Special Provisions 430-2QA. Acceptance and pay adjustment determinations made under Special Provisions 430-2QA will be completely independent of those made under this Special Provision.

(8) *Pay Adjustments Not Covered in Standard Specifications, Special Provisions 414-10QA or 430-2QA*. Adjustments in pay, for deviations from specified standards for characteristics other than those described in these Special Provisions (if any) will be made in accordance with General Provision 105.03.

(9) *Total Pay Adjustment for Entire Project.* The total adjustment in pay for the entire project is the sum of: (1) the pay adjustments for individual lots per Subsection (m)(6); plus (2) the pay adjustments for thickness per Standard Specifications 414-04(t)(3); plus(3) the pay adjustments for smoothness per Special Provision 430-2QA; plus (4) other pay adjustments, if appropriate, per Subsection (m)(8).

(10) *Extreme Values (Outliers)*. Test results apparently inconsistent with the results of the majority of test will also be closely examined by the Engineer in order to determine their validity. The examination will cover the procedures used in sampling and testing and , if necessary, a mathematical analysis performed in accordance with ASTM E 178 (upper 2.5% significance level). Test results thus determined by the Engineer to be non-representative of the material being evaluated will be discarded. The remaining test results will then be supplemented, if necessary.

(11) *Lot and Sublot Selection.* The concrete will be randomly sampled and tested for all control test characteristics except smoothness on a lot to lot basis in accordance with the following requirements. However, any load of mixture which is visually unacceptable for reasons of being too wet, excessively segregated or otherwise obviously deficient will be rejected for use in the work. Furthermore, sections of completed pavement which from visual observation or known deficiencies appear to be seriously inadequate will be extensively tested. The results of such tests will not be used for pay adjustment purposes but will be used to determine whether the section is totally unacceptable and must be removed. In the event that it is determined to be unacceptable, its removal and replacement shall be at no additional cost to the Department. A standard size lot will consist of six (6) equal sublots of 2500 Yd2 (m2) each. Any partial lot (one less than 15,000 Yd2 (m2)) resulting from completion or suspension of operations for more than seven calendar days shall be treated as a separate lot when five (5) or more sublots exist. When a lot contains four (4) or less sublots, it shall be combined with the previous lot. On a multiple project contract, the lots of the concrete will carry over from project to project within that contract. All acceptance testing shall be performed at a random location or time interval within each sublot in accordance with ASTM D 3665 or other acceptable means for ensuring random sampling of the materials.

(12) *Contractor's Testing and Engineer's Acceptance Procedures*. Once a lot has been defined, its identity will be maintained throughout the mixing and placement process. Pay factors, determined from random sampling and testing within the lot at appropriate locations, will be used in computing its payment adjustment.

The Contractor is required as a minimum to comply with the following schedule for sampling and testing. Depending upon the available time and his confidence in the Contractor's process control, the Engineer may elect to perform more or less sampling and

testing.

Gradation , slump and air content - one (1) specimen and one (1) test for each characteristic per sublot.
Strength - three (3) cylinders per sublot averaged and considered as one (1) test.
Thickness - In accordance with Subsection 414.04(t) (3) of the Standard Specifications.

(n) **Plant startup requirements.** Prior to beginning production of concrete, the Contractor shall provide a quality control system. The system shall include the fully-equipped laboratory and the full complement of quality control personnel that are to perform the quality control functions for the remainder of the project. Plant startup production shall be limited to that necessary to calibrate the plant, testing equipment and procedures using the approved mix design. The concrete thus produced shall be sampled and tested by both the Contractor and the Engineer as paired tests in accordance with Subsection (l)-5. The Contractor's test results shall thusly be reconciled with those from the Engineer. No concrete from the startup operation shall be placed in the pavement unless it meets one of the following requirements:

a. None of its characteristics have pay factors less than 1.00 or,
b. It is sufficiently uniform as defined in AASHTO M157.

Instead, adjustments shall continue to be made until all of the requirements are met. Concrete not meeting the requirements shall become the property of the Contractor. Costs associated with startup operations will not be measured separately for payment but will be included in the payment for Contractor's quality control.

Sample Size N=4										
Q	**0.00**	**0.01**	**0.02**	**0.03**	**0.04**	**0.05**	**0.06**	**0.07**	**0.08**	**0.09**
0.0	50.00	49.67	49.33	49.00	48.67	48.33	48.00	47.67	47.33	47.00
0.1	46.67	46.33	46.00	45.67	45.33	45.00	44.67	44.33	44.00	43.67
0.2	43.33	43.00	42.67	42.33	42.00	41.67	41.33	41.00	40.67	40.33
0.3	40.00	39.67	39.33	39.00	38.67	38.33	38.00	37.67	37.33	37.00
0.4	36.67	36.33	36.00	35.67	35.33	35.00	34.67	34.33	34.00	33.67
0.5	33.33	33.00	32.67	32.33	32.00	31.67	31.33	31.00	30.67	30.33
0.6	30.00	29.67	29.33	29.00	28.67	28.33	28.00	27.67	27.33	27.00
0.7	26.67	26.33	26.00	25.67	25.33	25.00	24.67	24.33	24.00	23.67
0.8	23.33	23.00	22.67	22.33	22.00	21.67	21.33	21.00	20.67	20.33
0.9	20.00	19.67	19.33	19.00	18.67	18.33	18.00	17.67	17.33	17.00
1.0	16.67	16.33	16.00	15.67	15.33	15.00	14.67	14.33	14.00	13.67
1.1	13.33	13.00	12.67	12.33	12.00	11.67	11.33	11.00	10.67	10.33
1.2	10.00	9.67	9.33	9.00	8.67	8.33	8.00	7.67	7.33	7.00
1.3	6.67	6.33	6.00	5.67	5.33	5.00	4.67	4.33	4.00	3.67
1.4	3.33	3.00	2.67	2.33	2.00	1.67	1.33	1.00	0.67	0.33
1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sample Size N=5										
Q	**0.00**	**0.01**	**0.02**	**0.03**	**0.04**	**0.05**	**0.06**	**0.07**	**0.08**	**0.09**
0.0	50.00	49.64	49.29	48.93	48.58	48.22	47.87	47.51	47.15	46.80
0.1	46.44	46.09	45.73	45.38	45.02	44.67	44.31	43.96	43.60	43.25
0.2	42.90	42.54	42.19	41.84	41.48	41.13	40.78	40.43	40.08	39.72
0.3	39.37	39.02	38.67	38.32	37.97	37.62	37.28	36.93	36.58	36.23
0.4	35.88	35.54	35.19	34.85	34.50	34.16	33.81	33.47	33.12	32.78
0.5	32.44	32.10	31.76	31.42	31.08	30.74	30.40	30.06	29.73	29.39
0.6	29.05	28.72	28.39	28.05	27.72	27.39	27.06	26.73	26.40	26.07
0.7	25.74	25.41	25.09	24.76	24.44	24.11	23.79	23.47	23.15	22.83
0.8	22.51	22.19	21.87	21.56	21.24	20.93	20.62	20.31	20.00	19.69
0.9	19.38	19.07	18.77	18.46	18.16	17.86	17.55	17.25	16.96	16.66
1.0	16.36	16.07	15.78	15.48	15.19	14.91	14.62	14.33	14.05	13.76
1.1	13.48	13.20	12.93	12.65	12.37	12.10	11.83	11.56	11.29	11.02
1.2	10.76	10.50	10.23	9.97	9.72	9.46	9.21	8.96	8.71	8.46
1.3	8.21	7.97	7.73	7.49	7.25	7.02	6.79	6.56	6.33	6.10
1.4	5.88	5.66	5.44	5.23	5.02	4.81	4.60	4.39	4.19	3.99
1.5	3.80	3.61	3.42	3.23	3.05	2.87	2.69	2.52	2.35	2.19
1.6	2.03	1.87	1.72	1.57	1.42	1.28	1.15	1.02	0.89	0.77
1.7	0.66	0.55	0.45	0.36	0.27	0.19	0.12	0.06	0.02	0.00
1.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sample Size N=6										
Q	**0.00**	**0.01**	**0.02**	**0.03**	**0.04**	**0.05**	**0.06**	**0.07**	**0.08**	**0.09**
0.0	50.00	49.63	49.27	48.90	48.53	48.16	47.80	47.43	47.06	46.70
0.1	46.33	45.96	45.60	45.23	44.86	44.50	44.13	43.77	43.40	43.04
0.2	42.68	42.31	41.95	41.59	41.22	40.86	40.50	40.14	39.78	39.42
0.3	39.06	38.70	38.34	37.98	37.62	37.27	36.91	36.55	36.20	35.84
0.4	35.49	35.14	34.79	34.43	34.08	33.73	33.38	33.04	32.69	32.34
0.5	32.00	31.65	31.31	30.96	30.62	30.28	29.94	29.60	29.26	28.93
0.6	28.59	28.25	27.92	27.59	27.26	26.92	26.60	26.27	25.94	25.61
0.7	25.29	24.96	24.64	24.32	24.00	23.68	23.37	23.05	22.74	22.42
0.8	22.11	21.80	21.49	21.18	20.88	20.57	20.27	19.97	19.67	19.37
0.9	19.07	18.78	18.49	18.19	17.90	17.61	17.33	17.04	16.76	16.48
1.0	16.20	15.92	15.64	15.37	15.09	14.82	14.55	14.29	14.02	13.76
1.1	13.50	13.24	12.98	12.72	12.47	12.22	11.97	11.72	11.47	11.23
1.2	10.99	10.75	10.51	10.28	10.04	9.81	9.58	9.36	9.13	8.91
1.3	8.69	8.48	8.26	8.05	7.84	7.63	7.42	7.22	7.02	6.82
1.4	6.63	6.43	6.24	6.05	5.87	5.68	5.50	5.33	5.15	4.98
1.5	4.81	4.64	4.47	4.31	4.15	4.00	3.84	3.69	3.54	3.40
1.6	3.25	3.11	2.97	2.84	2.71	2.58	2.45	2.33	2.21	2.09
1.7	1.98	1.87	1.76	1.66	1.55	1.45	1.36	1.27	1.18	1.09
1.8	1.01	0.93	0.85	0.78	0.71	0.64	0.57	0.51	0.46	0.40
1.9	0.35	0.30	0.26	0.22	0.18	0.15	0.12	0.09	0.07	0.05
2.0	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sample Size N=7										
Q	**0.00**	**0.01**	**0.02**	**0.03**	**0.04**	**0.05**	**0.06**	**0.07**	**0.08**	**0.09**
0.0	50.00	49.63	49.25	48.88	48.50	48.13	47.76	47.38	47.01	46.63
0.1	46.26	45.89	45.51	45.14	44.77	44.40	44.03	43.65	43.28	42.91
0.2	42.54	42.17	41.80	41.44	41.07	40.70	40.33	39.97	39.60	39.23
0.3	38.87	38.50	38.14	37.78	37.42	37.06	36.69	36.33	35.98	35.62
0.4	35.26	34.90	34.55	34.19	33.84	33.49	33.13	32.78	32.43	32.08
0.5	31.74	31.39	31.04	30.70	30.36	30.01	29.67	29.33	28.99	28.66
0.6	28.32	27.98	27.65	27.32	26.99	26.66	26.33	26.00	25.68	25.35
0.7	25.03	24.71	24.39	24.07	23.75	23.44	23.12	22.81	22.50	22.19
0.8	21.88	21.58	21.27	20.97	20.67	20.37	20.07	19.78	19.48	19.19
0.9	18.90	18.61	18.33	18.04	17.76	17.48	17.20	16.92	16.65	16.37
1.0	16.10	15.83	15.56	15.30	15.03	14.77	14.51	14.26	14.00	13.75
1.1	13.49	13.25	13.00	12.75	12.51	12.27	12.03	11.79	11.56	11.33
1.2	11.10	10.87	10.65	10.42	10.20	9.98	9.77	9.55	9.34	9.13
1.3	8.93	8.72	8.52	8.32	8.12	7.92	7.73	7.54	7.35	7.17
1.4	6.98	6.80	6.62	6.45	6.27	6.10	5.93	5.77	5.60	5.44
1.5	5.28	5.13	4.97	4.82	4.67	4.52	4.38	4.24	4.10	3.96
1.6	3.83	3.69	3.57	3.44	3.31	3.19	3.07	2.95	2.84	2.73
1.7	2.62	2.51	2.41	2.30	2.20	2.11	2.01	1.92	1.83	1.74
1.8	1.65	1.57	1.49	1.41	1.34	1.26	1.19	1.12	1.06	0.99
1.9	0.93	0.87	0.81	0.76	0.70	0.65	0.60	0.56	0.51	0.47
2.0	0.43	0.39	0.36	0.32	0.29	0.26	0.23	0.21	0.18	0.16
2.1	0.14	0.12	0.10	0.08	0.07	0.06	0.05	0.04	0.03	0.02
2.2	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sample Size N=8										
Q	**0.00**	**0.01**	**0.02**	**0.03**	**0.04**	**0.05**	**0.06**	**0.07**	**0.08**	**0.09**
0.0	50.00	49.62	49.24	48.86	48.49	48.11	47.73	47.35	46.97	46.59
0.1	46.22	45.84	45.46	45.08	44.71	44.33	43.96	43.58	43.21	42.83
0.2	42.46	42.08	41.71	41.34	40.97	40.59	40.22	39.85	39.48	39.11
0.3	38.75	38.38	38.01	37.65	37.28	36.92	36.55	36.19	35.83	35.47
0.4	35.11	34.75	34.39	34.04	33.68	33.33	32.97	32.62	32.27	31.92
0.5	31.57	31.22	30.87	30.53	30.18	29.84	29.50	29.16	28.82	28.48
0.6	28.15	27.81	27.48	27.15	26.82	26.49	26.16	25.83	25.51	25.19
0.7	24.86	24.54	24.23	23.91	23.59	23.28	22.97	22.66	22.35	22.04
0.8	21.74	21.44	21.14	20.84	20.54	20.24	19.95	19.66	19.37	19.08
0.9	18.79	18.51	18.23	17.95	17.67	17.39	17.12	16.85	16.57	16.31
1.0	16.04	15.78	15.51	15.25	15.00	14.74	14.49	14.24	13.99	13.74
1.1	13.49	13.25	13.01	12.77	12.54	12.30	12.07	11.84	11.61	11.39
1.2	11.17	10.94	10.73	10.51	10.30	10.09	9.88	9.67	9.47	9.26
1.3	9.06	8.87	8.67	8.48	8.29	8.10	7.91	7.73	7.55	7.37
1.4	7.19	7.02	6.85	6.68	6.51	6.35	6.19	6.03	5.87	5.71
1.5	5.56	5.41	5.26	5.12	4.97	4.83	4.69	4.56	4.42	4.29
1.6	4.16	4.03	3.91	3.79	3.67	3.55	3.43	3.32	3.21	3.10
1.7	2.99	2.89	2.79	2.69	2.59	2.49	2.40	2.31	2.22	2.13
1.8	2.04	1.96	1.88	1.80	1.72	1.65	1.58	1.51	1.44	1.37
1.9	1.31	1.24	1.18	1.12	1.07	1.01	0.96	0.91	0.86	0.81
2.0	0.76	0.72	0.67	0.63	0.59	0.55	0.52	0.48	0.45	0.42
2.1	0.39	0.36	0.33	0.30	0.28	0.26	0.23	0.21	0.19	0.17
2.2	0.16	0.14	0.13	0.11	0.10	0.09	0.08	0.07	0.06	0.05
2.3	0.04	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.00
2.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sample Size N=9										
Q	**0.00**	**0.01**	**0.02**	**0.03**	**0.04**	**0.05**	**0.06**	**0.07**	**0.08**	**0.09**
0.0	50.00	49.62	49.24	48.85	48.47	48.09	47.71	47.33	46.95	46.57
0.1	46.18	45.80	45.42	45.04	44.66	44.29	43.91	43.53	43.15	42.77
0.2	42.40	42.02	41.64	41.27	40.89	40.52	40.15	39.77	39.40	39.03
0.3	38.66	38.29	37.92	37.55	37.19	36.82	36.46	36.09	35.73	35.37
0.4	35.00	34.64	34.29	33.93	33.57	33.21	32.86	32.51	32.15	31.80
0.5	31.45	31.10	30.76	30.41	30.07	29.72	29.38	29.04	28.70	28.36
0.6	28.03	27.69	27.36	27.03	26.70	26.37	26.04	25.72	25.39	25.07
0.7	24.75	24.43	24.11	23.80	23.49	23.17	22.86	22.56	22.25	21.94
0.8	21.64	21.34	21.04	20.75	20.45	20.16	19.87	19.58	19.29	19.00
0.9	18.72	18.44	18.16	17.88	17.61	17.33	17.06	16.79	16.53	16.26
1.0	16.00	15.74	15.48	15.23	14.97	14.72	14.47	14.22	13.98	13.73
1.1	13.49	13.26	13.02	12.79	12.55	12.32	12.10	11.87	11.65	11.43
1.2	11.21	11.00	10.78	10.57	10.36	10.15	9.95	9.75	9.55	9.35
1.3	9.16	8.96	8.77	8.59	8.40	8.22	8.04	7.86	7.68	7.51
1.4	7.33	7.17	7.00	6.83	6.67	6.51	6.35	6.20	6.04	5.89
1.5	5.74	5.60	5.45	5.31	5.17	5.03	4.90	4.77	4.64	4.51
1.6	4.38	4.26	4.14	4.02	3.90	3.78	3.67	3.56	3.45	3.34
1.7	3.24	3.14	3.03	2.94	2.84	2.75	2.65	2.56	2.47	2.39
1.8	2.30	2.22	2.14	2.06	1.98	1.91	1.84	1.76	1.70	1.63
1.9	1.56	1.50	1.44	1.37	1.32	1.26	1.20	1.15	1.10	1.05
2.0	1.00	0.95	0.90	0.86	0.82	0.77	0.73	0.70	0.66	0.62
2.1	0.59	0.55	0.52	0.49	0.46	0.43	0.41	0.38	0.36	0.33
2.2	0.31	0.29	0.27	0.25	0.23	0.21	0.20	0.18	0.17	0.15
2.3	0.14	0.13	0.11	0.10	0.09	0.08	0.08	0.07	0.06	0.05
2.4	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.01	0.01
2.5	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sample Size N=10										
Q	**0.00**	**0.01**	**0.02**	**0.03**	**0.04**	**0.05**	**0.06**	**0.07**	**0.08**	**0.09**
0.0	50.00	49.62	49.23	48.85	48.46	48.08	47.70	47.31	46.93	46.54
0.1	46.16	45.78	45.40	45.01	44.63	44.25	43.87	43.49	43.11	42.73
0.2	42.35	41.97	41.60	41.22	40.84	40.47	40.09	39.72	39.34	38.97
0.3	38.60	38.23	37.86	37.49	37.12	36.75	36.38	36.02	35.65	35.29
0.4	34.93	34.57	34.21	33.85	33.49	33.13	32.78	32.42	32.07	31.72
0.5	31.37	31.02	30.67	30.32	29.98	29.64	29.29	28.95	28.61	28.28
0.6	27.94	27.60	27.27	26.94	26.61	26.28	25.96	25.63	25.31	24.99
0.7	24.67	24.35	24.03	23.72	23.41	23.10	22.79	22.48	22.18	21.87
0.8	21.57	21.27	20.98	20.68	20.39	20.10	19.81	19.52	19.23	18.95
0.9	18.67	18.39	18.11	17.84	17.56	17.29	17.03	16.76	16.49	16.23
1.0	15.97	15.72	15.46	15.21	14.96	14.71	14.46	14.22	13.97	13.73
1.1	13.50	13.26	13.03	12.80	12.57	12.34	12.12	11.90	11.68	11.46
1.2	11.24	11.03	10.82	10.61	10.41	10.21	10.00	9.81	9.61	9.42
1.3	9.22	9.03	8.85	8.66	8.48	8.30	8.12	7.95	7.77	7.60
1.4	7.44	7.27	7.10	6.94	6.78	6.63	6.47	6.32	6.17	6.02
1.5	5.87	5.73	5.59	5.45	5.31	5.18	5.05	4.92	4.79	4.66
1.6	4.54	4.41	4.30	4.18	4.06	3.95	3.84	3.73	3.62	3.52
1.7	3.41	3.31	3.21	3.11	3.02	2.93	2.83	2.74	2.66	2.57
1.8	2.49	2.40	2.32	2.25	2.17	2.09	2.02	1.95	1.88	1.81
1.9	1.75	1.68	1.62	1.56	1.50	1.44	1.38	1.33	1.27	1.22
2.0	1.17	1.12	1.07	1.03	0.98	0.94	0.90	0.86	0.82	0.78
2.1	0.74	0.71	0.67	0.64	0.61	0.58	0.55	0.52	0.49	0.46
2.2	0.44	0.41	0.39	0.37	0.34	0.32	0.30	0.29	0.27	0.25
2.3	0.23	0.22	0.20	0.19	0.18	0.16	0.15	0.14	0.13	0.12
2.4	0.11	0.10	0.09	0.08	0.08	0.07	0.06	0.06	0.05	0.05
2.5	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01
2.6	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Use of Contractor's Test Results for Acceptance Purposes

Part 1: Guidelines for Initial Validation of Contractor's Test Methods

In order to utilize the Contractor's material test results for acceptance and payment, the Department must ensure that the Contractor's results compare favorably with the Department's test results for the same material and same quality characteristic. The following procedure can be used to determine the initial validity of the Contractor's test methods:

1. A "paired test" (as referred to herein) will be any time two (2) separate tests are conducted by the Department and the Contractor (one test each) where the material tested has been collected as a true split sample or was sampled at the same time, from the same lot, sublot and batch, and from the same proximity within the batch. For asphalt air voids, asphalt cement content, and gradation testing, "paired" tests are those tests performed on split samples or samples taken from the same batch and from the same proximity within the batch. For roadway density and thickness measurements from cores, "paired" tests are those measurements performed on the exact same cores. For concrete unit weight, slump, and air content, "paired" tests are those conducted on samples taken from the same batch and from the same proximity within the batch. For concrete, the compressive strength "paired" test will generally be the average strength of two or three specimens each (by the Department and the Contractor). The specimens are cast from concrete sampled from the same batch and from the same proximity within the batch.

2. For each quality characteristic for which the Contractor's test methods are to be validated, the Department will conduct a minimum of ten (10) initial paired tests with the Contractor.

3. The Engineer may, at his discretion, exclude from this and subsequent analyses any paired test data that clearly exhibit explainable special-cause variation provided the cause of said variation has been identified and corrected so as to be unlikely to reoccur.

4. For each quality characteristic, calculate the paired-t test statistic (t_p), the average of the paired differences ($\overline{X}_p$) and the standard deviation of the paired differences (S_p) as follows:

$$t_p = \left| \sqrt{N_p} \frac{\overline{X}_p}{S_p} \right| \qquad \overline{X}_P = \frac{\sum_{i=1}^{N_P} \left(C_i - D_i \right)}{N_P} \qquad S_P = \sqrt{\frac{\sum_{i=1}^{N_P} \left(C_i - D_i - \overline{X}_P \right)^2}{N_{P-1}}}$$

Equation (1) Equation (2) Equation (3)

Where:

t_p = Paired-t test statistic. This value will be compared to a critical t-value (t_{crit}) to be obtained from Table 1.

N_p = The number of paired tests conducted. Each "paired test" consists of two individual tests (one by the Contractor and one by the Department) performed on a single split sample.

$\overline{X_p}$ = The average of the differences between the paired tests. This should not be confused with the difference between the averages. The correct order for computing $\overline{X_p}$ is to calculate all the differences between the paired tests, then take the average of those differences.

S_p = The standard deviation of the differences between the paired tests. As with $\overline{X_p}$, the correct order for computing S_p is to calculate all the differences between the paired tests, then take the standard deviation of those differences.

C_i = The Contractor's individual test result for a given split sample *i*.

D_i = The Department's individual test result for a given split sample *i*.

N_{p-1} = The number of degrees of freedom for use with Table 1.

5. Obtain the critical t-value t_{crit}, from Table 1, using N_{p-1} as the number of degrees of freedom.

6. Compare the calculated paired-t statistic (t_p) to the corresponding critical value from Table 1 (t_{crit}).

7. If t_p is less than t_{crit}, the Contractor's test methods for that quality characteristic are without significant bias. The Contractor's test methods for that quality characteristic can be considered valid at the present time. Proceed to Step 12.

8. If t_p is greater than or equal to t_{crit}, there exists a *statistically*-significant bias (= $\overline{X_p}$) between the Contractor's and the Department's test methods.

9. Compare the Contractor's testing bias ($\overline{X_p}$) to the relevant Allowable Testing Bias (ATB) from the following table:

PCC Quality	Allowable Testing Bias (ATB)	Units
Gradation:		
Sieve # 200 (Coarse)	± 0.40	%-passing
Sieve # 200 (Fine)	± 0.30	%-passing
Unit Weight	± 0.80	pcf
Slump	± 0.30	inch
Air Content	± 0.30	% (by volume)
Compressive Strength	± 100	psi

AC Quality Characteristic	Allowable Testing Bias (ATB)	Units
Gradation:		
Sieves #4 and larger	± 1.50	%-passing
Sieves #10 through #80	± 1.00	%-passing
Sieve # 200	± 0.50	%-passing
Asphalt Cement Content	± 0.15	% (by weight)
Air Voids (LMS)	± 0.50	% (by volume)
Roadway Density	± 0.50	% max. theor.

10. If the magnitude of $\overline{X_p}$ is less than the magnitude of the corresponding ATB, the Contractor's bias for that quality characteristic, though *statistically*-significant, is not practically

significant. The Contractor's test methods for that quality characteristic can be considered valid at the present time. Proceed to Step 12.

11. If the magnitude of $\overline{X}_p$ is greater than or equal to the magnitude of the corresponding ATB, the Contractor's bias for that quality characteristic is practically significant and unacceptable. The Contractor's test results for that quality characteristic will not be used for acceptance unless and until the Contractor's test methods are validated as follows:
    (1) The respective test equipment used during the paired testing (both the Contractor's and the Department's) shall be inspected and tested for calibration by a qualified independent calibration specialist.
    (2) A calibration test certificate shall be prepared by the calibration specialist identifying the pre-calibration errors at various measurement levels such that the paired test data are fully bracketed by the pre-calibration error estimates.
    (3) The paired test results will then be adjusted by the Engineer so as to effectively nullify the errors identified on each calibration test certificate.
    (4) Return to Step 4, using the adjusted paired test data in lieu of the original paired test data.

12. Once the Contractor's test methods for a given quality characteristic have been validated, the Engineer will provide ongoing validation of the Contractor's test method in accordance with the *Guidelines for Ongoing Validation of Contractor's Test Methods.*

Table 1 – Critical Values for the Paired-t Test Statistic (based on $\alpha = 0.01$)

Degrees of Freedom ($N_p - 1$)	Critical t-value (t_{crit})	Degrees of Freedom ($N_p - 1$)	Critical t-value (t_{crit})	Degrees of Freedom ($N_p - 1$)	Critical t-value (t_{crit})
2	9.925	25	2.787	48	2.682
3	5.841	26	2.779	49	2.680
4	4.604	27	2.771	50	2.678
5	4.032	28	2.763	60	2.660
6	3.707	29	2.756	70	2.648
7	3.499	30	2.750	80	2.639
8	3.355	31	2.744	90	2.632
9	3.250	32	2.738	100	2.626
10	3.169	33	2.733	110	2.621
11	3.106	34	2.728	120	2.617
12	3.055	35	2.724	130	2.614
13	3.012	36	2.719	140	2.611
14	2.977	37	2.715	150	2.609
15	2.947	38	2.712	160	2.607
16	2.921	39	2.708	170	2.605
17	2.898	40	2.704	180	2.603
18	2.878	41	2.701	190	2.602
19	2.861	42	2.698	200	2.601
20	2.845	43	2.695	300	2.592
21	2.831	44	2.692	400	2.588
22	2.819	45	2.690	500	2.586
23	2.807	46	2.687	1000	2.581
24	2.797	47	2.685	10000	2.576

Use of Contractor's Test Results for Acceptance Purposes

Part 2: Guidelines for Ongoing Validation of Contractor's Test Methods

After the Department has initially validated the Contractor's test method for a particular quality characteristic as outlined in the Guidelines for Initial Validation of Contractor's Test Methods, the following procedure will be used for ongoing validation of the Contractor's test methods for that quality characteristic. The ongoing validation will be performed by the Engineer through the creation and maintenance of a "testing-bias" control chart for that quality characteristic. The purpose of the control chart will be to document the bias (over time) between the Contractor's and the Department's testing procedures and to identify any changes that occur with the Contractor's (or Department's) test methods during the prosecution of the project. The following procedures are meant to guide the Engineer in the use of testing-bias control charts:

1. The values to be reported on the testing-bias control chart will be the differences (for that quality characteristic) between the Contractor's and the Department's test results for all paired tests conducted for that quality characteristic for the project. In general, "paired" tests are those tests performed on materials sampled at the same time, from the same batch and from the same proximity within the batch. The differences will be recorded and charted as $Ci - Di$, where Ci = the Contractor's individual test result for a given split sample i, and Di = the Department's individual test result for that same split sample.

2. In addition to the initial paired tests (performed during the initial validation of the Contractor's test methods), the Engineer will periodically conduct additional ongoing paired tests with the Contractor. The frequency of ongoing paired testing will, in general, be one (1) paired test per lot, but should not be less than one (1) paired test for every ten (10) sublots.

3. The control charts will be maintained and kept current and will follow the same guidelines and requirements as those specified for the Contractor's control charts in the *Control Charts for Quality Control.*

4. In the event an out-of-control condition is observed for testing bias,
   a) The Contractor and Engineer shall immediately investigate the probable cause.
   b) If the probable cause is identified and corrected or if the resulting bias is (according to the judgment of the Engineer) not likely to exceed the limits for Allowable Testing Bias (ATB) set forth in the *Guidelines for Initial Validation of Contractor's Test Methods,*
      i) Acceptance and pay adjustments for that quality characteristic will continue to be based on the Contractor's test results.
      ii) At the Engineer's discretion, the errant test results may be discarded from the acceptance and pay-adjustment calculations. If replacement test results are available (i.e. Department tests were performed on the same sublots as the discarded Contractor test results) the Department's test results may, at the Engineer's discretion, be substituted for the discarded test results.
   c) If the probable cause is not corrected and the resulting bias is (according to the judgment of the Engineer) likely to exceed the limits for Allowable Testing Bias (ATB) set forth in the Guidelines for Initial Validation of Contractor's Test Methods,
      i) All subsequent testing for that quality characteristic will be paired testing until such time as the source of the unacceptable testing bias is clearly identified and corrected and the validity of the Contractor's test methods has been re-established.

ii) During this period of 100% paired testing, acceptance and pay adjustments for that quality characteristic will be based on the Department's test results rather than the Contractor's.