

SUPPLEMENTAL SPECIFICATION
SECTION 501B - QC/QA PORTLAND CEMENT CONCRETE

501.01B DESCRIPTION. This work shall consist of supplying, placing and curing Quality Control/Quality Acceptance (QC/QA) structural portland cement concrete as shown on the plans or as ordered by the Engineer. Such work is to be accepted under Quality Acceptance (QA) provisions.

The portland cement concrete shall consist of a homogeneous mixture of cement, fine aggregate, coarse aggregate, water, admixtures, and pozzolan (when used), proportioned and mixed according to these Specifications.

501.02B MATERIALS. Materials shall meet the requirements of the following Subsections:

Portland Cement	701.02
Portland-Pozzolan Cement	701.05
Blended Silica Fume Cement	701.06
Tar Emulsion	702.05
Fine Aggregate for Concrete	704.01
Coarse Aggregate for Concrete	704.02
Asphalt-Treated Felt	707.08
PVC Waterstop	707.10
Concrete Curing Materials	725.01
Air-Entraining Admixtures	725.02(b)
Retarding Admixture	725.02(c)
Water-Reducing Admixture	725.02(f)
Water-Reducing and Retarding Admixture	725.02(g)
Water-Reducing, High Range Admixture	725.02(h)
Water-Reducing, High Range, and Retarding Admixture	725.02(i)
Accelerating Admixture	725.02(j)
Water-Reducing and Accelerating Admixture	725.02(k)
Mineral Admixtures	725.03
Silica Fume Admixture	725.03(b)
Ground Granulated Blast-Furnace Slag	725.03(c)
Polystyrene Insulation Board	735.01
Blanket Insulation Material	735.02
Pipe Insulation	740.08
Water	745.01

501.03B CLASSIFICATION AND PROPORTIONING. The following class of concrete is included in these Specifications and shall be used as shown on the Plans:

TABLE 501.03B - QC/QA (METRIC)

Cl. A	Maximum Water/ Cem. Mat. Ratio	Perme- ability (Cou- lombs)	Max. Perme- ability (Cou- lombs)	Air		28-Day Compr. Stress (Mpa) *	Concrete Cover (mm)
				Content (%)	Content (%)		
		LSL	USL	LSL	USL		
QC/ QA	0.44	---	7000	5.0	8.0	30	T (-13/+19)

TABLE 501.03B - QC/QA (ENGLISH)

Cl.A	Maximum Water/ Cem. Mat. Ratio	Perme- ability (Cou- lombs)	Max. Perme- ability (Cou- lombs)	Air Content (%)	Air Content (%)	28-Day Compr. Stress (psi)*	Concrete Cover (inches)
		LSL	USL	LSL	USL		
QC /QA	0.44	----	7000	5.0	8.0	4000	T(-.50/ +.75)

*Mix Design Target Value

LSL - lower specification limit,
 Cem. Mat. - Cementitious Material

(Max. 660 lbs./cy, 392 kg, m3),

USL - upper specification limit,

T - target value, defined as the typical clearance as shown on the Plans, or as directed by the Engineer, for each location to be evaluated. The LSL and USL for concrete cover are derived by subtracting or adding (respectively) the tolerance value (shown in parentheses in the table above) to the target value.

If a blended silica fume cement contains silica fume at a rate other than that specified in the approved mix design, the Contractor shall furnish additional silica fume or cement to provide concrete meeting the approved mix design. The additional cement or silica fume provided shall be of the same brand and type as contained in the silica fume cement blend.

A water-reducing, retarding, or water-reducing-retarding or water-reducing-high range or water-reducing-high range-retarding admixture shall be used for all Class A QC/QA concrete, unless otherwise authorized in writing by the Engineer. The use of an accelerating or water-reducing-accelerating admixture to alter the setting characteristics of concrete mixtures shall be employed only with the approval of the Engineer. The use of chlorides or admixtures containing chlorides is prohibited. All admixtures will be considered incidental to the work and included in the Contract unit price of the concrete.

A minimum of thirty (30) calendar days - thirty seven (37) calendar days, if the first time the mix is being submitted - prior to the pre-placement meeting, the Contractor shall submit (for approval) the mix design for the class of concrete specified. The mix design (s) shall be submitted to the Agency's Materials and Research Laboratory, National Life Building, Drawer 33, Montpelier, VT, 05633, Attention Structural Concrete Engineer. No class of concrete shall be placed on a project until the mix design is approved. The mix design must contain the following:

Compressive Strength

Cement Content in kg/cubic meter (lbs/cubic yard)

Mineral Admixture Content (each) in kg/cubic meter (lbs/cubic yard)

Air Content

Water/Cementitious Material Ratio

Chemical Admixtures (types, brand names, dosages)

Laboratory Test Results (strength, air content, water/cement ratio, slump)

The first time a Class A QC/QA mix design is submitted, the Contractor shall include (a minimum of) three four inch diameter x eight inch high test cylinders, made and cured in accordance with AASHTO T 22. These cylinders shall be sent to the Materials and Research Laboratory at least thirty seven (37) days prior to the pre- placement meeting. The specimens will undergo rapid chloride permeability testing. The cylinders shall be submitted when they are a minimum of twenty eight (28) days old and shall be tested between twenty eight (28) and fifty six (56) days old. In addition to other criteria, approval of the mix design will require permeability test results of 2000 (or less) Coulombs. Subsequent use of an approved design will not require submittal of cylinders for permeability testing.

The test cylinders shall be submitted with the following data regarding fabrication of the specimens:

- Size of Batch
- Type of Mixer
- Mixing Time
- Type of Cure
- Date cast

After the materials to be furnished by the Contractor have been approved, no change in the source or character of the materials shall be made without notice to the Engineer. No new materials shall be used until the Engineer has accepted such materials, and has designated or approved new proportions. In no case shall concrete from more than one batch plant be permitted on the same structure without prior written approval of the Engineer.

The class of concrete shall have an air content by volume as specified. The entrained air may be obtained by the use of an approved admixture.

Proportioning of the concrete mixtures containing mineral admixture(s) shall be by the absolute volumes method in accordance with the requirements as specified in Table 501.03B and the listed water/cementitious material ratio shall be based on total cementitious material (portland cement and mineral admixture). The volumetric proportioning method such as that outlined in ACI Standard 211.1, Recommended Practice for Selecting Proportions for Normal Weight Concrete, or other approved volumetric proportioning methods shall be employed in the mix design.

The Contractor, at its option, may propose a mix containing ground granulated blast-furnace slag (GGBFS), Grade 100 or 120 and portland cement. Fly ash and GGBFS will not be permitted in the same concrete mixture.

When using concrete with GGBFS, strength gain may be retarded in cool weather. When the ambient air temperature is 10 degrees C (50 degrees F) or less, the Resident Engineer, after consultation with the Agency's Structural Concrete Engineer and the Plan, may require that the curing period, as indicated in Subsection 501.17B, be extended.

501.04B - 501.05B. THESE SUBSECTIONS RESERVED.

501.06B FIELD TESTS. The Contractor shall provide assistance, equipment, materials, and curing for field sampling and testing as required by the Engineer. All costs shall be included in the Contract unit prices under Section 631. The Engineer shall perform all Quality Acceptance sampling and testing.

- (a) Sampling. Sampling for tests shall be taken in accordance with AASHTO T 141 or other procedures approved by the Agency.
- (b) Air Content Tests. Air content tests shall be made in accordance with the pressure method in AASHTO T 152, for acceptance or rejection.
- (c) Strength Tests.
 - (1) General. Strength tests shall be by test cylinders. A test shall be the average of the strengths of at least two specimens from the same sample of concrete.

Test Cylinders. Test cylinders shall be made and stored in accordance with AASHTO T 23, and tested for compressive strength in accordance with AASHTO T 22.

- (2) Categories of Testing.
 - a. Quality acceptance testing utilizes specimens to determine the compliance with strength requirements for the project. All test cylinders used for quality acceptance testing shall be stored in an approved curing box until they are shipped to the central laboratory.
 - b. Job control testing utilizes specimens to determine whether adequate curing procedures are being followed and for early form removal or early loading of structure as indicated in the Plan. All job control specimens shall be stored on the structure and shall receive the same curing and protection from the elements as the concrete that they represent.
 - c. Specimen curing requirements shall be as follows:

NUMBER OF SPECIMENS	CATEGORY	LOCATION OF CURING
2	Quality Acceptance - 28 days	Curing Box
2	Investigative - 14 days	Curing Box
2	Job Control - Applicable Curing Period	On Structure

501.07B. THIS SUBSECTION RESERVED.

501.08B QUALITY CONTROL/QUALITY ACCEPTANCE. The Contractor shall administer an approved Process Quality Control Plan for the QC/QA concrete class specified, hereafter called the "Plan," sufficient to insure a product meeting the Contract specifications. The Plan shall conform to Subsection 106.03B and the following provisions. The Plan shall also outline an agenda for a pre-placement meeting that shall take place at least 7 calendar days before concrete placement. The pre-placement meeting shall be attended by all participating parties, including but not limited to, the Contractor's Project Superintendent (the Contractor's representative), the Plan Administrator, and the designated on-site person for Agency contact. Representatives from the Contractor and supplier attending the pre-placement meeting are responsible for disseminating the information exchanged at this meeting to their employees assigned to the project. This will ensure the employees are prepared for the placement of concrete as detailed in the Plan and from the pre-placement meeting. The Plan shall be submitted for review 14 days before the pre-placement meeting. The Plan will be discussed at the meeting and re-submitted for final approval at least 5 working days before the first concrete placement.

If at any time the Engineer deems that elements in the approved Plan are not adhered to, he/she may suspend the concrete placement until such time that concrete can be produced and placed which meets the requirements in the approved Plan.

(a) QC Plan Elements. The Plan shall address according to the following outline all elements effecting the quality of structural concrete including, but not limited to:

1. Names, Certifications/Registrations and Qualifications of the Plan Administrator, PCT(s), QCT(s) and the Designated On-site Person for Agency Contact (who institutes any and all actions on the part of the Contractor for the Plan to be successful)
2. Lab Specifications and Testing Equipment
3. Process Quality Control Testing
4. Mix Design(s)
5. Aggregate Production
6. Stockpile Management
7. Delivery Ticket Information/Format - refer to Part (c), Subpart 1.
8. Batching, Mixing, Transportation and Delivery
9. Addition of Water and Admixtures
10. Time from Batching to Placement
11. Quality Control Tests to be Performed - refer to Part (c), Subpart 2.
12. Location of QC/QA Testing and Proposed Method(s) of Transporting Samples to Test Sites

13. Properties of Fresh Concrete (temperature, slump, air, unit weight, water/cementitious materials ratio)
 14. Corrective Actions Regarding Fresh Concrete Properties
 15. Placement, Consolidation and Finishing
 16. Curing Methods
 17. Protection of Concrete During Curing, Placement, and Consolidation, Including Temperature and Weather Conditions (e.g. insulated forms, blankets, heaters)
 18. Compressive Strength
 19. Permeability
 20. Patching Procedures and Materials for Core Holes and Concrete Surface Repairs
 21. Corrective Action Regarding Reinforcement Cover
- (b) QC Personnel Requirements. Personnel, meeting the following qualifications, are to perform the described duties.
- (1) Plan Administrator to perform duties as described in Subsection 106.03B, meeting one of the following qualifications:
 - a. Registered Professional Engineer licensed to practice in the State of Vermont with one year of highway experience acceptable to VAOT.
 - b. Engineer in Training with two years of highway experience acceptable to VAOT.
 - c. An individual with three years of highway experience acceptable to VAOT and a Bachelor of Science Degree in Civil Engineering Technology or Construction.
 - (2) Process Control Technician (s) (PCT)(s) shall utilize test results and other process control techniques to ensure the quality of aggregates and other mix ingredients and to control proportioning to meet the mix design (s). The PCT(s) shall periodically inspect all equipment used in batching and mixing to ensure its proper operation and that batching and mixing conform to the mix design and Contract requirements.

The PCT(s) shall be New England Transportation Certification Program (NETTCP) Concrete Technician certified. A minimum of one PCT shall be required at the batch plant.

- (3) Quality Control Technician (s) (QCT)(s) shall perform and utilize quality control tests on project to ensure delivered materials meet mix design specifications including temperature, air content, water/cement ratio and strength. The QCT(s) shall inspect all equipment to be used in transporting concrete. The Plan shall detail frequency of sampling and testing, corrective actions to be taken, and documentation. The QCT(s) shall be ACI Concrete Field Testing Technician - Grade 1 certified.
- (4) The Contractor's representative shall be certified as a NETTCP Concrete Inspector. The representative shall inspect all equipment to be used for placing, consolidating, finishing and curing of concrete to ensure its proper operation and conformance with Contract requirements.

(c) Quality Control.

- (1) QC Delivery Record. For each load of concrete delivered to the project, the Contractor shall provide a Delivery Record which shall include the following:

Contract Name and Number
Concrete Supplier/Facility
Contractor (prime)
Date
Time (charged)
Truck Number
Load Number
Quantity Batched (load/total)

The Target Mass (Weight) per Cubic Meter (per Cubic Yard) and Actual Batched Mass (Weight) per cubic Meter (per Cubic Yard) for: Cement, Mineral Admixtures, Coarse Aggregate, Fine aggregate, Water (batched), and Chemical Admixtures (brands, types and dosages)

Aggregate Moisture Content (%)

The Delivery Record shall be signed by the PCT confirming the accuracy of the information.

The QCT shall add the following information to the Delivery Record at the construction site:

Time of Discharge

Concrete Temperature at Time of Discharge from Mixer

Amount of Water and Admixtures Added on Site

Final Water/Cementitious Material Ratio

The Delivery Record shall be signed by the QCT confirming the accuracy of the information.

- (2) QC Testing. The plastic concrete shall be sampled, tested and evaluated by the Contractor in accordance with the minimum requirements of Table 2:

Table 2 - Minimum Process Quality Control Requirements

PROPERTY	TEST FREQUENCY	TEST METHOD
Slump, if specified in the QC Plan	First 3 loads/class. Then as needed to control operations, or when visual change or change on the Delivery Record occurs	AASHTO T 119
AIR CONTENT *	SAME AS ABOVE	AASHTO T 152
Strength	As needed to control operations	AASHTO T 22 and T 23
Water/Cementitious Material Ratio **	Per load	As per approved Plan
Concrete Temperature	Per load	AASHTO T 309

*Concrete not meeting the Plan minimum requirements for air content shall not be used in the work.

**Water/cementitious material ratio will be controlled by a method prescribed in the approved Plan.

(d) Quality Acceptance.

- (1) QA Testing. Structural concrete to be accepted under Quality Acceptance (QA) provisions shall be randomly sampled once per subplot. QA samples will not be taken until the Contractor has approved the material for placement. Sampling will be in accordance with AASHTO T 141. Samples will be tested and evaluated by the Agency in accordance with Subsection 106.03B and the following Table 3 - Acceptance Testing Schedule, and further criteria presented in this subsection.

Table 3 - Acceptance Testing Schedule

PROPERTY	POINT OF ACCEPTANCE	MAXIMUM SIZE OF SUBLOT	TEST METHOD
Strength	Point of Placement	38 Cubic Meters (50 Cubic Yards)	AASHTO T 22 and T 23
Permeability	Point of Placement	38 Cubic Meters (50 Cubic Yards)	AASHTO T 277
Air Content	Point of Placement	See 2.a. (below)	AASHTO T 152
Concrete Cover	Point of Placement	Each Data Point	See 2. c. (below)

- (2) Lot Size. For evaluation purposes of all acceptance test properties a lot shall be made up of the total accepted quantity of QC/QA concrete in each bridge deck.
- a. A QC/QA concrete lot shall be evaluated by equal size sublots: a minimum of three sublots; 38 cubic meters (50 cubic yards) maximum quantity for each subplot. For air content a minimum of one test will be required per subplot if six (or a greater number of) sublots are determined. Otherwise, a minimum of six tests per lot are required.
 - b. Rapid Chloride Permeability Tests shall be performed by the Materials and Research Section at an age of 56 days or later. One core will be taken per subplot placed, with no fewer than three cores per lot. Any epoxy coated reinforcing bars damaged during coring shall be repaired per Subsection 507.04 of the Standard Specifications for Construction.
 - c. Concrete cover of rebar shall be determined by a Materials and Research Section approved method or device. To perform cover evaluations the superstructure shall have a constant moisture and no standing water present. The Engineer will give five day notice of the evaluation date.

Measurements of the concrete cover over reinforcing steel will be taken as follows: Each travel lane. Shoulders less than 1.2 m (4'-0") in width shall be included and measured with the adjacent lane. Shoulders 1.2 m (4'-0") and wider will be measured separately. Coping areas and areas where the cross slope breaks will not be measured. At least 90% of measurable deck area shall be represented by concrete cover measurements. A depth verification hole for calibration will be drilled each day or as necessary to verify measurements.

Epoxy coated bar reinforcement shall be repaired as outlined under "b." above and the QC Plan.

- (3) Random Sampling Locations. Sampling locations for quality acceptance tests must be selected entirely at random. These procedures shall be used to determine sampling locations so as to eliminate any intentional bias and minimize any unintentional bias on the part of the person(s) sampling.

Sampling locations shall be determined on the basis of either volume or area. Random numbers are to be selected using the procedures that follow. The random numbers shall be applied to the sublots (and lot) to determine sampling locations.

- a. Sampling Bridge Deck Material, In-Place. Determine the total length and width of the subplot. Use Method #1 or #2 to select a random number to determine each width and length. Multiply the width and length by the random numbers to find the sampling location.

Example: Each permeability subplot - area determined by 38 cubic meters (50 cubic yards) - is 15.24 m (50 feet) long and 10.97 m (36 feet) wide. Select a random number using Method #1 or Method #2. Multiply this number by the length: Say $0.336 \times 15.24 \text{ m} = 5.12 \text{ m}$ ($0.336 \times 50 \text{ feet} = 16.8 \text{ feet}$). Select another random number, and multiply it by the width. Say $0.883 \times 10.97 \text{ m} = 9.69 \text{ m}$ ($36 \text{ feet} \times .883 = 31.8 \text{ feet}$). Therefore, the sample will be taken 5.12 m (16.8 feet) from the beginning of the subplot, and 9.69 m (31.8 feet) from the designated (left or right) face of curb.

- b. Sampling Trucks. Using Method #1 or Method #2 select a random number. The subplot quantity shall be multiplied by the random number to determine which truck to sample.

Example: A subplot of concrete is 38 cubic meters (50 cubic yards) and the random number selected is 0.653. Thus the sample would be taken out of the 25th cubic meter (33rd cubic yard) of the subplot, since $0.653 \times 38 = 25$ ($0.653 \times 50 = 33$).

- c. Selecting Random Numbers.

1. Method #1. Table 106-3 is comprised of all numbers from 0.001 to 1.000. Each number appears only once. Using a pointed object such as a pen or pencil, point without looking, to a number in the table. Use either page alternating between each selection. Use the first two digits of the number to locate the line (vertical column on the left) to be used in locating the random number. Repeat the procedure without looking and point to another number. Use the first digit to pick the column (horizontal numbers across the top). The random number is found at the table intersection indicated by these two numbers.

2. Method #2. Obtain a random number by using a random number generator function found on some hand-held calculators, or on some computer spread sheet programs.

- (e) Compressive Strength, Pay Adjustment Factors, Rejected Sublots. Evaluation of materials shall be in accordance with the specifications set forth in Subsection 501.03B.

- (1) Concrete with compressive strength greater than that specified is not eligible for any bonus payment calculation.
- (2) Concrete failing to meet (less than) the compressive strength at 28 days, average of two cylinders per subplot, will be evaluated as follows:
 - a. If the difference between the design and the actual compressive strength ($f'c - f'ca$) is less than 415 kPa (60 psi) the concrete will be accepted with no pay adjustment applied.
 - b. If the difference ($f'c - f'ca$) is between 415 kPa (60 psi) and 3450 kPa (500 psi) the Engineer may:
 1. Require corrective action at no expense to the Agency, or
 2. Accept the concrete with a calculated pay adjustment in accordance with the following:
$$\text{Sublot Pay Adjustment Factor} = 0.0000725(f'ca - f'c),$$
$$[0.0005(f'ca - f'c)]$$

Where: $f'ca$ = actual compressive strength at 28 days: kPa,psi

$f'c$ = specified compressive strength at 28 days: kPa,psi
 - c. If the difference ($f'c - f'ca$) is greater than 3450 kPa (500 psi) the subplot is considered rejected and the Engineer shall :
 1. Require removal and replacement at no expense to the Agency, or
 2. Require corrective action at no expense to the Agency

Sublot Pay Adjustment Factors for replaced or remedied subplot quantities will be determined once these quantities of concrete are in place and accepted.

Alternately, the Contractor may submit a proposal for acceptance of rejected sublots at further reduced (less than 75%) measurement for payment. Such a request must include engineering analysis explaining expected effects upon performance and durability of such subplot materials. The Engineer shall determine whether or not the materials may remain in place per the Contractor's proposal.

- (f) Permeability, Pay Adjustment Factors, Rejected Sublots. Evaluation of materials shall be in accordance with the specifications set forth in Subsection 501.03B.

For sublots with core readings from zero to 800 Coulombs the Sublot Pay Adjustment Factor shall be 0.03.

For sublots with core readings from 801 to 2000 Coulombs the Sublot Pay Adjustment Factor shall be equal to $0.03(1-(C-800)/1200)$, where C equals the charge passed in Coulombs.

For sublots with core readings from 2001 to 3500 Coulombs the Sublot Pay Adjustment Factor shall be equal to $-0.15(C-2000)/1500$, where C equals the charge passed in Coulombs.

For sublots with core readings from 3501 to 7000 Coulombs the Sublot Pay Adjustment Factor shall be -0.25

For sublots with core readings greater than 7000 Coulombs the sublot is considered rejected and the Engineer shall require removal and replacement or corrective action at no expense to the Agency. Sublot Pay Adjustment Factors for replaced or remedied sublot quantities will be determined once these quantities of concrete are in place and accepted. Alternately, the Contractor may submit a proposal for acceptance of rejected sublots at further reduced (less than 75%) measurement for payment. Such a request must include engineering analysis explaining expected effects upon performance and durability of such sublot materials. The Engineer shall determine whether or not the materials may remain in place per the Contractor's proposal.

- (g) Air Content and Concrete Cover, Pay Adjustment Factors, Rejected Lots. Evaluation of materials shall be in accordance with the specifications set forth in Subsection 501.03B and Subsection 106.03B.

For lots with PWL (total percent within limits) per Table 2 of Subsection 106.03B, The Lot Pay Adjustment Factor shall be determined by the same table. Note that the Pay Adjustment Factor for air content or concrete cover is determined from the Pay Factor from Table 2 minus 1.00. However, the maximum bonus Lot Pay Adjustment Factors for air content and concrete cover shall be limited to 0.03 each.

For lots with PWL below the rejected lot limit of Table 2 the lot is considered rejected and the Engineer shall require removal and replacement or corrective action at no expense to the Agency. The Lot Pay Adjustment Factor for a replaced or remedied lot will be determined once the quantity of concrete is in place and accepted. Alternately, the Contractor may submit a proposal for acceptance of a rejected lot at further reduced (less than 75%) measurement for payment. Such a request must include engineering analysis explaining expected effects upon performance and durability of such lot materials. The Engineer shall determine whether or not the materials may remain in place per the Contractor's proposal.

501.09B FORMS. All forms, materials and construction procedures shall conform to the following specifications unless otherwise modified in the approved Plan.

If required by the Engineer, falsework and form work plans shall be submitted by the Contractor for approval before being used. In all cases, the Contractor shall be responsible for, and shall make good, any injury arising from inadequate forms. The Engineer shall inspect and approve all forms prior to concrete placement. Unless the Plans specifically call for the use of stay-in-place forms, such forms shall not be used in the construction of any superstructure or bridge deck.

Stay-in-place forms will only be allowed in the construction of substructure elements in locations where the Engineer agrees that removable formwork is impossible to use.

- (a) Falsework. In general, falsework that cannot be founded upon a solid footing shall be supported by falsework piling.

The Engineer may require the Contractor to employ screw jacks or hardwood wedges to take up any slight settlement in the falsework.

- (b) Construction. Forms shall be mortar tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other loads incident to the construction operations including vibration. Forms shall be constructed and maintained so as to prevent the opening of joints due to shrinkage of the lumber. Sealer/caulking as approved by the Engineer shall be used where forms abut structural steel members, such as top flanges of beams and girders, etc.

Forms shall be filleted and chamfered at all sharp corners, unless otherwise shown on the Plans or directed by the Engineer, and shall be given a bevel or draft in the case of all projections, such as girders and copings to ensure easy removal.

Falsework and forms for slabs, beams, and girders shall be constructed to provide camber shown on the Plans or ordered by the Engineer.

- (c) Form Lumber. All face form lumber for exposed surfaces shall be concrete form exterior grade plywood, not less than five ply and not less than 19 mm (3/4 inch) in thickness. In computing stud spacing, plywood shall be considered 25 mm (1 inch) lumber provided that the grain of three of the plys runs perpendicular to the studs.

Form lumber for unexposed surfaces may be dressed tongue and groove, dressed shiplap, or square edged and surfaced four sides, of uniform width and thickness. It shall have a minimum thickness, after finishing, of 19 mm (3/4 inch).

All form lumber shall be sound and free from loose or rotten knots, knotholes, checks, splits, or waness showing on the surface in contact with the concrete. Used face form lumber, having defects or patches which may produce work inferior to that resulting from new material, shall not be used.

Other form material may be used with permission of the Engineer.

- (d) Studs. Studs shall have a minimum nominal size of 50 by 150 mm (2 × 6 inches), except that 50 by 100 mm (2 × 4 inch) nominal size studs may be used for pours not exceeding 1.1 m (3 1/2 feet) in height. Studs shall be spaced center to center not more than 16 times the actual thickness of the form lumber.

Studs shall be capped at the top with a plate of not less than 50 by 150 mm (2 × 6 inches) nominal size, carefully selected as to straightness. All joints in plates shall be scabbed 1.2 m (4 feet) each way to provide continuity.

- (e) Wales. All wales shall be at least 100 by 150 mm nominal size (4 × 6 inches, minimum section) or equivalent and shall be scabbed at least 1.2 m (4 feet) each side of joints to provide continuity. A row of wales shall be placed within 150 mm (6 inches) of the bottom of each pour unless studding can be extended below the bottom of the pour and secured by wales fastened to ties in the previous pour. Wales shall have a maximum spacing of 900 mm (36 inches). As approved by the Engineer, alternate types of wales and spacing will be allowed.

- (f) Form Ties. Metal ties or anchorages within the forms shall be constructed to permit their removal to a depth of at least 25 mm (1 inch) from the face without injury to the concrete.

Wire ties shall be used only in locations where they will not extend through surfaces exposed in the finished work and then only when authorized.

The cavities shall be filled with cement mortar in accordance with Subsection 501.15B.

- (g) Walls. Where the bottom of the form is inaccessible, the lower form boards shall be left loose or other provisions made so that extraneous material may be removed from the form immediately before placing the concrete.

- (h) Surface Treatment. All forms shall be treated with commercial form oil prior to placing reinforcement and wood forms shall be saturated with water immediately before placing the concrete. Any material that will adhere to or discolor the concrete shall not be used.

- (i) Metal Forms. The specifications for forms regarding design, mortar tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse, and oiling also apply to metal forms. The metal used for forms shall be of such thickness that the forms will remain true to shape. All bolt and rivet heads shall be countersunk. Clamps, pins, or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms that do not present a smooth surface or do not line up properly shall not be used. Care shall be exercised to keep metal forms free from rust, grease, or other foreign matter.

- (j) Removal of Forms. The forms, or their supports, for any portion of a structure shall not be removed without the approval of the Engineer. Forms under arches, beams, floor slabs, pier caps, or special designs may be removed upon approval of the Engineer after the concrete attains 85 percent of the minimum compressive strength as specified in Table 501.03B, or as specified in the QC Plan.

When field operations are controlled by strength tests, the removal of forms and supports may begin when the concrete is found to have the required strength. In no case shall the number of curing days be less than specified in the QC Plan.

Methods of form removal likely to cause overstressing of the concrete shall not be used. Forms and their supports shall not be removed without approval. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own dead load.

501.10B PLACING CONCRETE.

- (a) Blasting Operation. All blasting operations within 60 m (200 feet) of any concrete work shall be completed prior to the placement of the concrete. Regardless of the above limitation on blasting operations, the Contractor shall be responsible for any damage resulting from blasting operations.

501.11B - 501.12B. THESE SUBSECTIONS RESERVED.

501.13B CONSTRUCTION JOINTS.

- (a) Location of Construction Joints. Joints shall be formed at the location shown on the Plans. Any variation or new location of joints shall require written permission of the Engineer. Feather edges at construction joints will not be permitted and joints shall be so formed with inset form work that each layer of concrete will have a thickness of not less than 150 mm (6 inches).
- (b) Joining Fresh Concrete to Previously Set Concrete. In joining fresh concrete to concrete that has hardened, the surface shall be roughened in such a manner that will not leave loosened particles or damaged concrete at the surface and be thoroughly cleaned of all laitance, loose, and foreign material. Immediately prior to the placing of the new concrete, the surface shall be saturated with water. When shown on the Plans or ordered by the Engineer, the surface shall be thoroughly coated with a very thin coating of mortar or neat cement grout and all forms drawn tight against the face of the concrete. The neat cement mortar or bonding agent shall not be allowed to dry out before being covered with fresh concrete.
- (c) Keys. Suitable keys shall be formed at construction joints. Unless otherwise directed by the Engineer, these keys shall be of the type and detail shown on the Plans.

- (d) Filled Construction Joints. Filled construction joints shall contain a preformed cork joint filler or other preformed joint filler that may be shown in the Contract Documents. Joint filler shall be cut to fit exactly and shall completely fill the space that is shown on the Plans. Where a pour grade or caulking grade filler is indicated to be used in the joints, that portion of the joint to be filled shall be formed with a separate material (other than the preformed joint filler) that can easily be removed prior to placement of the above indicated filler.
- (e) Water Stops. Approved water stops shall be placed at locations shown on the Plans. They shall form continuous watertight joints.
- (f) Bond Breakers. Bond breakers shall be one of the following materials as shown on the Plans: asphalt-treated felt, pipe insulation, or tar emulsion.

501.14B EXPANSION JOINTS. All joints shall be constructed according to details shown on the Plans.

- (a) Filled Compression and Expansion Joints. Filled compression and expansion joints shall be made with a preformed self-expanding cork joint filler or other preformed joint filler that may be shown in the Contract Documents. Joint filler shall be cut to fit exactly and shall completely fill the space that is shown on the Plans. Where a pour grade or caulking grade filler is indicated to be used in the joint, that portion of the joint to be filled shall be formed with a separate material (other than the expansion joint filler) that can easily be removed prior to placement of the above indicated filler.
- (b) Special Types of Expansion Joints. Special types of expansion joints may be used when so shown on the Plans or ordered by the Engineer.

501.15B PATCHING. Patching of new concrete shall be as specified in the QC Plan.

501.16B . THIS SUBSECTION RESERVED.

501.17B CURING CONCRETE. Superstructures shall be continuously wet cured for ten days by any of the following methods: a) Pre-soaked burlap with a lapped overcoat of white polyethylene sheeting. b) Pre-dampened cotton mats. c) Pre-dampened white burlap-polyethylene sheeting. d) Any other reasonable means of curing, described and approved as part of the QC Plan.

The QC Plan shall address the prompt application of the continuous wet cure process. This process shall promptly follow the screed machine, within a maximum lag time of 10 minutes and without interruption.

Exact materials, methods and details of the curing shall be presented within the QC Plan for approval.

501.18B LOADING OF CONCRETE. After the concrete has been placed and the finishing operations concluded, it shall not be walked on or disturbed in any manner, including removal of forms, for a minimum period of 18 hours. If retarder is used as an admixture, this minimum period may be extended as directed by the Engineer.

- (a) Superstructure. Static loads, such as forms, granite curbing, cast-in-place concrete curb, and other materials necessary for deck construction, may be placed on deck concrete as long as the field cured test cylinders for this concrete have attained 85 percent of the compressive strength specified in Table 501.03B, the proper curing is maintained, and the materials are spread out uniformly to avoid point loading.

The Contractor shall keep bridge floors free of all motor vehicles, transit mixers, and heavy construction equipment until the curing period is satisfactorily completed, the field cured test cylinders for the bridge floor concrete have attained the compressive strength specified in Table 501.03B, and the field cured test cylinders for the curb concrete have attained 85 percent of the compressive strength specified.

- (b) Vertical Joint. Concrete shall not be placed against a vertical construction joint until the previously placed concrete has been in place a minimum of 72 hours.

The Contractor must not allow loads that are in excess of the legal loads permitted by the laws of the State to travel over the completed structure, except with written permission of the Engineer.

501.19B METHOD OF MEASUREMENT. The lot quantity of Concrete, Class A QC/QA to be measured for payment will be the number of cubic meters (cubic yards) of the class of concrete specified in the complete and accepted work, as determined by the prismoidal method using dimensions shown on the Plans or as directed by the Engineer. No deductions will be made for the volume of concrete displaced by steel reinforcement, structural steel, expansion joint material, scuppers, weep holes, conduits, tops of piles, scoring, chamfers or corners, inset panels of 38 mm (1 1/2 inches) or less in depth, or any pipe less than 200 mm (8 inches) in diameter.

Accepted lot (and subplot) quantities shall be adjusted by the application of Sublot and Lot Pay Adjustment Factors as determined per Subsection 501.08B to determine a Total Adjusted Lot Quantity for payment.

An adjustment quantity for a subplot will be determined by multiplying the subplot quantity times the sum of its respective Sublot Pay Adjustment Factors for compressive strength and permeability. This can be a negative or positive adjustment quantity. A resultant lot quantity will be determined by multiplying the lot quantity (measured per the requirements of the first paragraph of this subsection) times its combined Lot Pay Adjustment Factors (for air content and concrete cover) and adding the result (this can be negative or positive quantity) to the lot quantity. The sum of all subplot adjustment quantities and the resultant lot quantity shall be the Total Adjusted Lot Quantity for payment.

Example: 3 sublots with no rejected lot or sublots:

$TALQ = SL1 (SLPAF1str + SLPAF1per) + SL2 (SLPAF2str + SLPAF2per) + SL3 (SLPAF3str + SLPAF3per) + L + L (LPAFair + LPAFcover)$

Where: TALQ = Total Adjusted Lot Quantity for payment,

SL = subplot quantity, L = lot quantity, LPAF = Lot Pay Adjustment Factor,

SLPAF = Sublot Pay Adjustment Factor, str = compressive strength, per = permeability, air = air content, cover = concrete cover

However, for projects without rejected lot or subplot quantities (per Subsection 501.08B) the Total Adjusted Lot Quantity for payment shall not be less than 65% of the quantity determined per the requirements of the first paragraph of this subsection.

501.20B BASIS OF PAYMENT. The Total Adjusted Lot Quantity of Concrete, Class A QC/QA will be paid for at the Contract unit price. Payment will be full compensation for performing the work specified, including satisfactory finishing and curing, and for furnishing all forms, materials including joint filler and bond breaker, labor, tools, admixtures, equipment, trial batches, and incidentals necessary to complete the work.

The cost of heating materials and protecting the concrete against cold weather, and any additional cost for cement, will not be paid for separately but will be considered incidental to the Contract unit prices for Section 501B.

The costs of providing automatic temperature recording units to monitor concrete curing temperatures as required under the QC Plan will be paid for under the Contract item Testing Equipment - Concrete.

The cost of furnishing testing facilities and supplies at the batch plant and the setting of inserts, bench marks, and bridge plaques furnished by the Agency will not be paid for separately but will be considered incidental to the Contract unit price of structural concrete.

The costs for repairing reinforcing bars and core/verification holes and concrete surfaces will not be paid for separately, but will be considered incidental to the Contract unit price of structural concrete.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
501.221 Concrete, Class A QC/QA	Cubic Meter (Cubic Yard)