3.2.2 Removing deteriorated concrete to a sound concrete surface free of laitance, dirt, or other foreign material shall be done by power brushing, the use of jackhammers where their use is allowed, sawing, sandblasting, waterblasting, mechanical abrading, hosing with water, air-blast cleaning, or other approved methods. If reinforcing steel is exposed when removing concrete to a sound surface, or if exposure of the reinforcing steel in prepared areas is required by the plans, the minimum depth of removal shall be 1-1/2 in (40 mm) behind the main reinforcing steel. If reinforcing steel is not exposed when removing concrete to a sound surface, and if exposure of the reinforcing steel in prepared areas is not required by the plans, the minimum depth of removal shall be 1/2 in (15 mm) plus the maximum coarse aggregate size of the patching material.

3.2.3 The edges of all prepared areas shall be saw cut to a minimum depth of 1/2 in (15 mm) plus the maximum coarse aggregate size of the patching material. On vertical surfaces, if forms are to be used, the shape of the areas to be patched shall be such that the entire area to be patched is easily accessible, as determined by the Engineer. Although an occasional distribution or tie reinforcing bar may be cut, main reinforcing steel shall not be saw cut except as shown on the plans.

3.2.4 Reinforcing steel or other steel to be in contact with the new concrete shall be cleaned of all grease, dirt, concrete mortar and injurious rust. Injurious rust shall be interpreted to mean rust which is not firmly bonded to the steel. Rust which is difficult to remove by vigorous scrubbing with a wire brush shall be considered firmly bonded to the steel.

Method of Measurement

4.1 Preparation for concrete repairs will be measured by the square yard (square meter) to the nearest 0.1 of a square yard (square meter) as determined by actual surface measurements of the lengths and widths of all the surfaces prepared.

4.2 Areas prepared to a sound surface without exposing reinforcing steel will be measured as Class I preparation areas. Areas prepared to a sound surface a minimum of 1-1/2 in (40 mm) behind the reinforcing steel will be measured as Class II preparation areas.

Basis of Payment

5.1 The accepted quantity of preparation for concrete repairs will be paid for at the Contract unit price per square yard (square meter) complete.

Pay items and units:

512.01	Preparation for Concrete Repairs, Class I	Square Yard (Square Meter)
512.02	Preparation for Concrete Repairs, Class II	Square Yard (Square Meter)

SECTION 520 -- PORTLAND CEMENT CONCRETE

DESCRIPTION 227
MATERIALS 229
2.1 CEMENT 229
2.2 AGGREGATES. 230
2.3 CHEMICAL ADMIXTURES 232
2.4 BLANK 233

2.5 WATER. 233
2.6 CURING MATERIALS FOR CONCRETE..... 233
2.8 WATERSTOPS. 234
2.9 CONCRETE BONDING AGENT..... 234
2.10 STORAGE OF CONCRETE MATERIALS. 234
2.11 CONCRETE MIXES..... 235
CONSTRUCTION REQUIREMENTS 238
3.1 PROPORTIONING AND BATCHING..... 238
3.2 FORMS AND FALSEWORK. 246
3.3 WEEPERS AND DRAINS..... 247
3.4 READY-MIXED CONCRETE..... 247
3.5 PLACING CONCRETE. 249
3.6 JOINTS. 253
3.7 CONCRETING IN COLD WEATHER..... 254
3.9 FINISHING PLASTIC CONCRETE..... 255
3.10 CURING CONCRETE. 256
3.11 LOADING CONCRETE..... 259
3.12 FINISHING. 259
METHODS OF MEASUREMENT 260
BASIS OF PAYMENT 261
409

Description

1.1 General. This work shall consist of furnishing and placing portland cement concrete of the classes specified including fly-ash, silica fume, or ground granulated blast furnace slag as shown on the plans or as ordered.

1.1.1 The work also consists of furnishing, placing, and curing structural portland cement concrete as shown on the plans or as ordered, to be accepted under Quality Assurance (QA) provisions.

1.2 Classes of concrete. The following classes of concrete are included in these specifications Table 1A - Method and Table 1B - Performance (QC/QA).

Table 1A - Classes of Concrete

Concrete Class	Minimum Expected 28 Day Compressive Strength1	Maximum Water/Cement Ratio2	Entrained Air Percent	Permeability Target Value[6]
	PSI (Mpa)			Coulombs
AAA3 AAA	5,000 (35) 5,000 (35)	0.400 0.444	5 to 9 5 to 9	2000
AA3	4,000 (30)	0.400	5 to 9	2000
AA	4,000 (30)	0.444	5 to 9	2000
A	3,000 (20)	0.464	4 to 7	4000
B	3,000 (20)	0.488	3 to 6	
T	3,000 (20)	0.559	----	
F	304 (0.2)	3.0 to 4.05	15 to 255	

[1] See 3.1.6 TESTING

[2] For mixes containing fly-ash, silica fume, slag, or any other pozzolanic or cementitious material, the water/cement ratio of the concrete mix shall be based on the water cementitious (cement + pozzolanic or cementitious material) ratio of the mix. This water to cementitious ratio shall not exceed those listed in Table 1A. The maximum water/cement ratios listed for Concrete Class B and T are for design purposes only.

[3] Deck Overlays.

[4] Maximum 84 day Compressive Strength for Flowable Fill, Excavatable shall not exceed 200 psi (1.4 Mpa).

[5] These are recommended values that may be used as a starting point for a mix design that has shown ability to meet the requirements. The amount of cement shall be adjusted and fly-ash or ground granulated blast furnace slag shall be used provided the mix design meets the minimum and does not exceed the maximum compressive strength in accordance with 2.11.1.

[6] Target values shown are for mix design approval only and are not intended for use as quality control or quality assurance requirements.

Table 1B - Class Of Concrete – Performance Requirements (QC/QA)

CONCRETE	MINIMUM 28 DAY COMPRESSIVE STRENGTH	PERMEABILITY	AIR CONTENT		WATER/CEMENT RATIO		CONCRETE COVER
CLASS	PSI (MPa)	Coulombs	Percent		Percent		in (mm)
		Maximum	LSL	USL	***LSL***	USL	TV ± T
AA	4.000 (30.00)	7,000	5.0	9.0	Mean - 0.030	Mean + 0.030	1/2 (T = ± 12)
A	3,000 (20.00)	7,000	4.0	----	----	----	----
B	3,000 (20.00)	-----	3.0	----	----	----	----

LSL - lower specification limit
USL - upper specification limit
Mean - calculated mean of all test results for a lot.
TV - Target Value[1]
T - Tolerance

[1] Target value is defined as the typical clearance as shown on the plans or as ordered by the Engineer, for each location to be evaluated.

1.2.1 Unless otherwise shown on the plans, the specified class of concrete shall be used in the following applications.

1.2.1.1 Method Requirements.

(a) Footing concrete shall be Class B.
(b) Concrete above footings shall be Class A.
(c) Abutment backwall concrete shall be Class AA.
(d) Concrete bridge decks shall be Class AA.

(e) Concrete foundation seals shall be Class T.

(f) Class F, Flowable Fill, Excavatable may be specified or requested in writing as a substitute for compacted gravel in embankment, granular backfill, structural fill, and pipe backfill. Approval in the form of a supplementary agreement shall be in consideration of, but not limited to, differential frost heaving due to dissimilar materials, unit weight structural requirements, lack of permeability, and damming resulting from water flow cut off. Flowable fill will not be allowed in lieu of pavement. Class F, Flowable Fill shall be a flowable, self-consolidating, rigid setting and low density material.

(g) Precast concrete shall be Class AAA.

1.2.1.2 Performance Requirements (QC/QA).

(a) Footing concrete shall be Class B.

(b) Substructure concrete above footings shall be Class A except as shown in (c) and (d) below.

(c) At grade approach slab concrete shall meet the requirements of and be paid as QC/QA Concrete Class AA, Item 520.0302X_Concrete Class AA Approach Slabs (QC/QA).

(d) Concrete bridge decks, copings, bridge sidewalks, abutment backwalls, and wing copings, shall meet the requirements of and be paid as QC/QA Concrete Class AA, Item 520.7X02_ Concrete Bridge Deck (QC/QA).

(e) Concrete in rail support slabs shall meet the requirements of, and be paid as, QC/QA Concrete Class AA, Item 520.0202X_ Concrete Class AA, Rail Support Slab (QC/QA).

(f) Class F, Flowable Fill, Excavatable may be specified or requested in writing as a substitute for compacted gravel in embankment, granular backfill, structural fill, and pipe backfill. Approval in the form of a supplementary agreement shall be in consideration of, but not limited to, differential frost heaving due to dissimilar materials, unit weight structural requirements, lack of permeability, and damming resulting from water flow cut off. Flowable fill will not be allowed in lieu of pavement. Class F, Flowable Fill shall be a flowable, self-consolidating, rigid setting and low density material.

(g) Precast concrete shall be Class AAA.

1.2.2 Retarding admixtures and Type G high range water reducing (HRWR) admixtures shall not be used in deck concrete when the existing air temperature is below 50º F (10º C) or forecasted to drop below 50º F (10º C) within 24 hours after completion of placement.

Materials

2.1 Cement.

2.1.1 Portland cement shall be Type II, or Type IP conforming to AASHTO M 85 or M 240 as appropriate, unless otherwise shown on the plans or permitted. Mill test reports shall be furnished with each delivery of cement.

2.1.2 Cement used in visible portions of the work shall be the same brand, type, and color unless otherwise permitted.

2.1.3 Cement containing lumps or partial set shall not be used.

2.1.4 Supplemental Cementitious Materials

2.1.4.1 Fly-Ash and Ground Granulated Blast Furnace Slag.

2.1.4.1.1 Fly-ash shall conform to Class C or Class F as described in AASHTO M 295 and shall meet the requirements of 2.2.4.3. Ground Granulated Blast Furnace Slag (GGBFS) shall be Grade 120 slag meeting the requirements of AASHTO M 302.

2.1.4.1.2 Only one source of fly-ash or ground granulated blast furnace slag shall be used on any one project.

2.1.4.1.3 Requirements. Fly-ash shall conform to the chemical, physical and methods of sampling and testing requirements of AASHTO M 295 except that the CaO content shall be 8% or less and in the optional physical requirement, the multiple factor shall be 120 percent maximum. In addition, the fly-ash shall be subjected to the Air-Entrainment of Mortar Test as listed in ASTM C 311 and shall conform to the requirements as listed in the optional physical requirements of AASHTO M 295 for the uniformity requirements. Ground granulated blast furnace slag shall conform to the chemical, physical, and methods of sampling and testing requirements of Ground Iron Blast Furnace Slag for Use In Concrete and Mortars as listed in AASHTO M 302 except that the slag shall meet the requirement for slag activity index Grade 120.

2.1.4.1.4 Certification. The Contractor shall furnish the Department three copies of the materials test results and certification from each fly-ash or ground granulated blast furnace slag source proposed for use. The certification shall state the fly-ash or ground granulated blast furnace slag used on the project meets the requirement as stated in 2.1.4.1.3 and shall be for a specific, identifiable quantity.

2.1.4.1.5 Fly-ash produced from a particular source shall be tested by the Contractor for loss on ignition and fineness at the frequency of one test per 100 tons (90 metric tons)) used. Complete testing of fly-ash shall be done by the Contractor at a frequency of one test per 400 tons (350 metric tons) of fly-ash used or as directed by the Department.

2.1.4.1.6 Under the direction of the Department, fly-ash or ground granulated blast furnace slag shall be sampled by approved means and shall be placed into a sealed container.

2.2 Aggregates.

2.2.1 General.

2.2.1.1 All aggregates shall be thoroughly washed unless otherwise permitted. Aggregates shall be stockpiled for a minimum of 24 hours before use.

2.2.1.2 The Contractor shall make arrangements for the Engineer to secure samples from all stockpiles in sufficient time to complete testing prior to starting concrete operations. If the stockpiled aggregates are approved, similar aggregates from the same sources will be considered acceptable, subject to the restrictions of the item for which the aggregates are to be used. No change in the source or character of the aggregates shall be made without prior notification to and approval by the Bureau of Materials and Research. Failure of any test taken prior to starting each placement will result in cancellation of the placement until corrective measures have been taken and the aggregates have been approved.

2.2.1.3 Unless frozen aggregates are dispersed during mixing, they shall not be permitted.

2.2.2 Method Requirements.

2.2.2.1 Fine Aggregate.

2.2.2.1.1 Fine aggregate shall consist of sand, stone screenings, or other inert materials with similar characteristics, or a combination thereof. Tests for organic impurities shall be in accordance with AASHTO T 21 and T 71.

2.2.2.1.2 Required grading:

Table 2 - Fine Aggregate

Sieve Size	Percentage by Weight Passing
3/8 inch (9.5 mm)	100
No. 4 (4.75 mm)	95 – 100
No. 16 (1.18 mm)	45 – 80
No. 50 (0.300 mm)	10 – 30
No. 100 (0.150 mm)	2 – 10
No. 200 (0.075 mm)	0 – 3

2.2.2.1.2.1 The gradation of fine aggregate from any source shall be reasonably uniform and the fineness modulus as determined by AASHTO M 6 shall lie between 2.5 and 3.1. Fine aggregate showing a variation in fineness modulus greater than 0.2 above or below that upon which the mix was designed may be rejected.

2.2.2.1.3 The requirements of 2.2.2.1.2 will not apply to fine aggregate for concrete class F, flowable fill. For concrete class F the fine aggregate grading shall be submitted with the mix design.

2.2.2.2 Coarse Aggregate.

2.2.2.2.1 Coarse aggregate shall consist of crushed stone, gravel, or other approved inert materials with similar characteristics or combinations thereof, having hard, strong, durable particles, free from surface coating and injurious amounts of soft, friable, or laminated pieces, and free of alkaline, organic, or other harmful matter. Material passing the No. 200 (0.075 mm)) sieve as determined by AASHTO T 11 shall not exceed 1.0 percent by weight. Thin or elongated particles shall not exceed 10 percent by number as determined by ASTM D 4791, on a 3 to 1 ratio and a minimum of 100 particles. The percent of wear shall not exceed 40 as determined by AASHTO T 96.

2.2.2.2.2 Required grading:

Table 3 - Coarse Aggregate

Class of Concrete	A[1], B, and T	A, AA, and AAA	Overlay
Standard Stone Size	467	67	89
Nominal Size	1- 1/2 inch to No. 4 (37.5 to 4.75 mm)	3/4 inch to No. 4 (19.0 to 4.75 mm)	3/8 inch to No. 16 (9.5 to 1.18 mm)
SIEVE SIZE	PERCENTAGE BY WEIGHT PASSING		
2 inch (50 mm)	100		
1- 1/2 inch (37.5 mm)	95 - 100		
1 inch (25.0 m)		100	
3/4 inch (19.0 mm)	35 - 70	90 – 100	
1/2 inch (12.5 mm)			100
3/8 inch (9.5 mm)	10 - 30	20 – 55	90 - 100
No. 4 (4.75 mm)	0 - 5	0 – 10	20 - 55
No. 8 (2.36 mm)		0 – 5	5 - 30
No. 16 (1.18 mm)			0 - 10
No. 50 (0.300 mm)			0 - 5

[1] 1-1/2 inch (37.5 mm) maximum size coarse aggregate for Class A concrete may only be used with approval of the Administrator, Bureau of Materials and Research.

2.2.2.2.3 Unless otherwise specifically permitted, coarse aggregate shall be furnished and stockpiled in a minimum of 2 sizes and the amount of each size to be used shall be determined by combining the individual gradations of each stockpile mathematically to provide a well graded mixture conforming to Table 3.

2.2.3 Performance Requirements (QC/QA).

2.2.3.1 Follow general requirements for aggregate section 2.2.1.

2.3 Chemical Admixtures.

2.3.1 Air-entraining admixtures shall meet the requirements of AASHTO M 154. If the Contractor requests permission to use an unfamiliar air-entraining admixture, evidence shall be submitted to prove that the admixture complies with AASHTO M 154. The evidence shall be based on tests performed in a laboratory of a state transportation department, the FHWA, or in a laboratory which is regularly inspected by the Cement and Concrete Reference Laboratory of the National Bureau of Standards. Tests may be made on samples taken from a quantity submitted and certified by the manufacturer as representative of the admixture to be supplied.

2.3.1.1 When using high range water reducing admixture the air entrainment admixture shall be a Vinsol Resin or approved equal conforming to AASHTO M 154.

2.3.2 Water-reducing admixtures shall meet the requirements of AASHTO M 194, Type A.

2.3.2.1 Water-reducing, high-range admixtures shall conform to AASHTO M 194 Type F or Type G.

2.3.2.2 Corrosion inhibitor admixtures shall conform to AASHTO M 194 (ASTM C 494) Type C.

2.3.3 Water-reducing and retarding admixtures (herein referred to as retarding admixtures) shall meet the requirements of AASHTO M 194, Type D.

2.3.4 Calcium chloride may only be used with specific permission of the Bureau of Materials and Research.

2.3.5 Chemical admixtures shall be products as included on the Qualified Products List.

2.3.6 Admixtures shall be stored in a suitable building in such a manner as to permit easy access and identification and to protect the admixtures from freezing. Admixtures will be rejected if precipitation has occurred in the container.

2.3.7 Silica Fume shall conform to AASHTO M307, Microsilica for use in Concrete and Mortar.

2.3.7.1 Bags used to supply silica fume shall not be incorporated into the concrete.

2.4 Blank.

2.5 Water.

2.5.1 Water for use in concrete shall be free from oils, acids, organic matter or other deleterious substances and shall not contain more than 500 parts per million of chlorides as Cl nor more than 1000 parts per million of sulfates as SO_4. In addition water used in portland cement concrete shall be free from iron, tannic acid, and other impurities which may cause staining or discoloration.

Water from municipal supplies approved by the State of New Hampshire Department of Environmental Services will not require testing, but water from other sources will be sampled and tested before being used in concrete, once per source unless otherwise directed. Tests shall be made in accordance with AASHTO T 26. A sample of approximately 1 gallon (2 liters) will be obtained by Department personnel.

The hydrogen ion concentration (pH) shall be determined electrometrically or colorimetrically and be between pH 4.5 and pH 8.5.

The water shall not contain any impurities in amounts sufficient to cause unsoundness or marked change in the time of setting in the cement with which it is mixed, nor a reduction in mortar strength of more than 10 percent compared to the results obtained with distilled water.

2.6 Curing Materials for Concrete.

2.6.1 Burlap shall conform to AASHTO M 182. The use of worn burlap, burlap with holes, or burlap reclaimed from uses other than curing concrete will not be permitted.

2.6.2 Sheet materials shall be waterproof paper, polyethylene film, or white burlap-polyethylene sheeting conforming to AASHTO M 171.

2.6.3 Liquid curing compound shall be Type ID (fugitive dye), Class B or Type 2 (white pigmented), Class B conforming to AASHTO M 148 except as modified herein. The vehicle shall have a resin base and contain no waxy compounds. The compound shall dry to touch within 4 hours when applied at the rate of 1 gallon per 200 square feet (2 liters per 10 square meters) of concrete.

2.6.3.1 Liquid curing compound shall be a product as included on the Qualified Products List.

2.6.4 Cotton mats shall consist of a filling material of cotton "batting" 12 oz/square yard (minimum 400 grams/square meter); covered with unsized cloth 6 oz/Square Yard (minimum 200 grams/square meter); tufted or stitched to maintain stability. Mats shall be free from tears and shall be in good condition.

2.6.5 Water for curing shall meet the requirements of 2.5, above.

2.7 Preformed expansion joint fillers. Preformed expansion joint fillers for concrete shall conform to AASHTO M 153, Type II, unless Type III is shown on the plans.

2.8 Waterstops.

2.8.1 Waterstops shall conform to 541.

2.9 Concrete Bonding Agent.

2.9.1 Concrete bonding agent shall be a product as included on the Qualified Products List and shall be used only where shown on the plans or ordered.

2.9.2 Grout for bonding bridge deck overlays to existing concrete shall consist of equal parts by weight of portland cement and sand, mixed with sufficient water to form a slurry. The consistency of this slurry shall be such that it can be applied with a stiff brush or broom to the old concrete in a thin, even coating that will not puddle in low spots. For sealing vertical joints around repair or between adjacent lanes of overlay and at the curbs, this grout shall be thinned to paint consistency.

2.10 Storage of Concrete Materials.

2.10.1 The handling and storage of concrete materials shall be such as to prevent their segregation or contamination by foreign materials. When directed, the aggregates shall be stored on suitable platforms or on clean, level, paved surfaces if segregation or contamination continues to occur. Aggregates shall be stored in separate stockpiles sufficiently removed from each other to prevent the aggregates from becoming intermixed. To prevent spillage from one bin to the next, buckets used to fill the bins shall not be wider than the clear opening of the bins. Evidence of intermixing, segregation, or contamination will be cause for rejection.

2.10.2 Unless otherwise permitted, cement shall be stored in approved weatherproof silos or buildings which will protect the cement from dampness. The floors of the buildings shall be sufficiently clear of the ground to prevent the absorption of moisture. When storage in the open is permitted, the cement shall be placed on raised platforms and completely covered with a waterproof covering.

2.10.3 The locations of the stockpiles and the facilities for storing cement shall be subject to approval.

2.10.4 Storage of Fly-Ash or Ground Granulated Blast Furnace Slag.

2.10.4.1 The approved fly-ash or ground granulated blast furnace slag shall be stored in weather-tight storage facilities at the source and the concrete plant. The storage facilities shall be subjected to approval by the Department. All storage facilities shall be completely empty and clean before fly-ash or ground granulated blast furnace slag is deposited therein unless they contain fly-ash of the same type from the same source.

2.10.4.2 Fly-ash or ground granulated blast furnace slag from different sources or of different types shall not be stored together in the same storage container. Adding fly-ash or ground granulated blast furnace slag to partially filled storage containers shall be allowed only for fly-ash or ground granulated blast furnace slag of the same type from the same source. Fly-ash added to a partially filled storage container shall not vary from the fly-ash in the container by more than ± 0.5% in Loss on Ignition and by more than ± 5% in Fineness.

2.10.4.3 Fly-ash or ground granulated blast furnace slag remaining in bulk storage for a period greater than one year after completion of test will be resampled and retested before shipment or use. However, fly-ash or ground granulated blast furnace slag which has been in bulk storage more than two years from the time of original manufacture shall not be used. Fly-ash or ground granulated blast furnace slag stored over the winter at the concrete producing plant shall be retested for specification compliance.

2.10.5 Shipping fly-ash or ground granulated blast furnace slag shall be in accordance with accepted techniques for bulk portland cement or as directed by the Department.

2.11 Concrete Mixes.

2.11.1 General

2.11.1.1 The concrete mix shall be composed of a mixture of aggregate, cement, supplemental cementitous materials, water, and chemical admixtures as required. All concrete mix designs shall provide for mitigation of alkali silica reactivity by the following:

2.11.1.1.1 The Contractor shall supply laboratory test reports that contain data on the mineralogy and potential reactivity for all aggregates being used in the concrete mix. All aggregates shall be tested in accordance with the requirements of AASHTO T 303 to determine alkali-silica reactivity. The laboratory supplying the test results shall provide evidence that the laboratory is properly equipped and qualified to perform the test methods. All test results submitted for alkali-silica reactivity shall be from tests conducted within one calendar year from the date the mix design is submitted to the Department.

2.11.1.1.1 Mix designs using potentially alkali reactive aggregates shall include mitigation for reactivity and shall be submitted to the Department for approval. Mitigation of potentially reactive aggregates shall consist of one or more of the following methods: use of low alkali cement (less than 0.6 percent Na_2O equivalent); use of a mineral admixture; or use of a chemical admixture. The proposed mitigation method will be accepted for use after the NHDOT Bureau of Materials and Research reviews test results supplied by the Contractor that show the effectiveness of the mitigation. An effective mitigation technique shall reduce the mean expansion to below 0.10% for alkali-silica reactivity when tested in accordance with ASTM C 1567.

In lieu of the above, mitigation may be by substitution of a minimum 25% fly-ash or 50% ground granulated blast furnace slag for cement by weight

2.11.2 Method Requirements

2.11.2.1 The Contractor shall submit a mix design appropriate for the raw materials and blends of approved aggregates available for the specific project. The concrete mix design limits given in Table 4 or Table 5 indicate the master ranges of mixes permissible under this specification. The mix design shall be within the master ranges indicated for the particular class of concrete specified. The mix design for each mix shall establish a single percentage of aggregate passing each required sieve size in accordance with Table 4 and Table 5, a cement factor and a water cement ratio, target strength and target permeability as

shown in Table 1A. Approval of the mix design will include a tolerance range of +/- 1000 coulombs. Consideration for values below 1000 coulombs will be made for mix designs utlizing ternary blends developed to mitigate for ASR. Gradings which range from the maximum of one sieve size to the minimum of the next will not be permitted. Mix design submittals shall include results of strength and permeability testing. Strength test results shall be comprised of two test cylinders tested for compressive strength at 28 days (a set of two averaged to comprise one strength test) in accordance with AASHTO T 22 & 23. Rapid Chloride Permeability testing shall be completed in accordance with AASHTO T 277 at an age of 56 days. No concrete placement shall be started on a project until the Bureau of Materials and Research has approved the mix design for that placement. The mix design for each mix shall be in effect until modified in writing by the Bureau of Materials and Research.

2.11.2.2 Should a change in sources of material be made, a new mix design shall be submitted per 2.11.2. When unsatisfactory results or other conditions make it necessary, the Engineer may establish a new mix design.

2.11.2.1.2 Except for Class F, aggregate fractions shall be sized, uniformly graded and combined in such proportions that the resulting mix meets the grading requirements of Table 4 or Table 5

2.11.2.1.2 Alternate mix designs for excavatable flowable fill and other categories of flowable fill, will be allowed, providing the mix design for each is approved by the Bureau of Material and Research. Other categories of flowable fill might include non-excavatable, ultra-light weight, very flowable or other combinations. Alternative flowable fill mix designs would be used when specified or ordered. All mix designs submitted for approval shall be accompanied by 5 test cylinders, which will be used to determine compressive strength, unit weight and excavatability. Test cylinders will be evaluated at 84 days. Compressive strength test cylinders will be prepared according to ASTM D 4832, as modified by NHDOT Test Procedure P-2.

2.11.2.5 Master Ranges for Combined Aggregates.

Table 4 - Coarse Aggregate with Specific Gravity Less Than 2.700

Sieve Size	Concrete Classes* A[1], B, and T			Concrete Classes** A, AA, and AAA		
	Min.	Desired	Max.	Min.	Desired	Max.
	(PERCENT BY WEIGHT PASSING)			(PERCENT BY WEIGHT PASSING)		
1-1/2 inch (37.5 mm)	95	100	100			
1 inch (25.0 mm)		80			100	
3/4 inch (19.0mm)	56	68	80	94	97	100
1/2 inch (12.5 mm)		57			77	
3/8 inch (9.5 mm)	38	46	55	51	62	73
No. 4 (4.75 mm)	31	35	39	37	42	47
No. 8 (2.36 mm)		29			34	
No. 16 (1.18 mm)	16	23	30	19	27	35
No. 30 (0.600 mm)		14			17	
No. 50 (0.300 mm)	4	7	10	4	8	12
No. 100 (0.150 mm)	1	2	3	1	2	4
No. 200 (0.075 mm)	0	0	2	0	0	2

*Class A[1], B, and T based on fine aggregate content of 32 to 36 percent of the total aggregate.

**Class A, AA and AAA based on fine aggregate content of 38 to 42 percent of the total aggregate.

[1] See footnote to Table 3.

Table 5 - Coarse Aggregate with Specific Gravity 2.700 and Over (Metric)

Sieve Size	Concrete Classes* A[1], B, and T			Concrete Classes** A, AA, and AAA		
	Min.	Desired	Max.	Min.	Desired	Max.
	(PERCENT BY WEIGHT PASSING)			(PERCENT BY WEIGHT PASSING)		
1 1/2 inch (37.5 mm)	97	100	100			
1 inch (25.0 mm)		83			100	
3/4 inch (19.0 mm)	57	69	82	95	97	100
1/2 inch (12.5 mm)		61			81	
3/8 inch (9.5 mm)	45	52	59	55	65	76
No. 4 (4.75 mm)	36	40	44	42	47	53
No. 8 (2.36 mm)		34			40	
No. 16 (1.18 mm)	20	27	35	22	31	40
No. 30 (0.600 mm)		17			19	
No. 50 (0.300 mm)	4	8	12	5	9	14
No. 100 (0.150 mm)	1	2	4	1	2	4
No. 200 (0.075 mm)	0	0	2	0	0	2

* Class A[1], B. and T based on fine aggregate content of 38 to 42 percent of the total aggregate.

**Class A, AA, and AAA based on fine aggregate content of 44 to 48 percent of the total aggregate.

[1] See footnote to Table 3.

2.11.3 Performance Requirements (QC/QA)

2.11.3.1 Aggregate fractions shall be sized, uniformly graded, and combined in such proportions, that the resulting mix meets the grading requirements of the Contractor's concrete mix design.

2.11.3.2 Thirty (30) days prior to the first concrete placement for each class of concrete specified, a concrete mix design shall be submitted to the Bureau of Materials and Research for approval. No class of concrete shall be placed on a project until its mix design is approved. The mix design shall contain the following:

Compressive Strength
Amount of Cement lb/cy (kg/cm) (including supplemental cementitous materials)
Fine and Coarse Aggregate Gradation
Air Content
Water/Cement Ratio
Chemical admixtures (types, Brand names, dosage ranges).
Laboratory test results (Strengths, Air Content, W/C ratios, Slump)

2.11.3.3 Should a change in sources of material be made, a new mix design shall be submitted per 2.11.3.2. When unsatisfactory results or other conditions make it necessary, the Engineer will require a new mix design.

Construction Requirements

3.1 Proportioning and Batching.

3.1.1 Proportioning.

3.1.1.1 All ingredients shall be measured by weight unless otherwise permitted. Scales shall be approved beam type with a separate tare beam or springless dial type, accurate to within 0.5 percent of the total load.

3.1.1.2 Cement shall be weighed on a separate scale. Weights for bagged cement, when its use is permitted, shall be as specified on the bag; fractional bags shall not be used.

3.1.1.3 Aggregate weights shall be saturated surface dry weights adjusted for moisture.

3.1.1.4 Mixing water shall consist of free moisture on the aggregates, ice if added, and water added to the batch. Water added to the batch shall be measured by weight or an approved volumetric method to an accuracy of 1 percent. Water meters shall be so installed that they are unaffected by pressure or temperature changes in the water supply. Graduated tanks shall be equipped with outside taps and valves for checking their calibration.

3.1.1.5 Each approved admixture shall be added to a separate portion of the fine aggregate or water as recommended by the manufacturer to eliminate premixing of the additives. Separate calibrated standpipes with positive action discharge tubes, readily visible from the batching area, shall be provided at all concrete producing plants regardless of metering devices.

3.1.1.6 The ratio of substitution of cement to fly-ash or cement to ground granulated blast furnace slag shall be 1:1 by weight.

3.1.1.7 When specified on the plans, corrosion inhibitor (calcium nitrate) admixture shall be as shown on the Department's Qualified Products List. Corrosion inhibitor shall be used at the rate recommended by the manufacturer unless otherwise directed by the Engineer.

3.1.2 Batching.

3.1.2.1 Batch plants shall meet the requirements of AASHTO M 157 except as modified herein. The plants shall have one bin for fine aggregate and one bin for each required size of coarse aggregate. Each bin shall discharge efficiently and freely into the weighing hopper.

3.1.2.2 All new, replaced, or major modification of existing batching plants shall be equipped for fully automatic proportioning and batching of all ingredients including admixtures.

3.1.2.2.1 Automatic batching plants shall be controlled by means of an approved automatic batch selector set to accurately deliver in proper sequence the designed mix proportions and admixtures required for the batch. The batch selector controls shall be locked and sealed during operation. Changes in selector controls or weight settings shall not be made without authorization. Provisions shall be made to vary the size of the batch without affecting the proportions of the design mix.

3.1.2.2.2 All batch equipment in automatic plants shall be interlocked to prevent the discharge of any ingredient into the system until all batching controls have been cleared of the previous batch and the discharge gates and supply valves are closed.

3.1.2.2.3 A moisture meter equipped with automatic adjustable compensating controls shall be installed to accurately and continuously measure the moisture content of the fine aggregate. The moisture compensating dial shall automatically adjust the amount of batch water added and the batch weight of the fine aggregate consistent with the variations of free moisture in the fine aggregate.

3.1.2.2.4 If the automatic proportioning devices become inoperable or malfunction during a concrete placement, the plant may operate manually for the completion of the pour. If the breakdown is readily correctable or is due to a condition within the producer's control, the plant will not be permitted to operate. If unavailability of parts or service or any condition beyond the producer's control exists, written permission may be given to operate the plant manually for a specified period. Accuracy shall be maintained as specified in 3.1.1.

3.1.3 Testing Equipment and Facilities.

3.1.3.1 Method Requirements.

3.1.3.1.1 The necessary equipment as specified and ordered shall be provided at all batch plants. Approved enclosed space for the use of the Engineer for storage and use of the testing equipment shall be provided including proper lighting, ventilation, and heat. The equipment shall include the following:

(a) Set of 8 inch (200 mm) brass sieves, full height- 2 inch (50 mm), sizes 3/8 inch, Nos. 4, 8, 16, 30, 50, 100, 200, (9.5 mm, 4.75 mm, 2.36 mm, 1.18 mm, 0.600 mm, 0.300 mm, 0.150 mm, 0.075 mm) with pan and cover.
(b) Motor driven shaker for 8 inch (200 mm) sieves.
(c) Scale, 2 000 grams capacity, 0.1 gram sensitivity.
(d) Approved motor drive mechanical shaker, tray size 18 by 26 in (460 by 660 mm), 2-1/3 ft^2 (0.2 m^2); screen sizes 1-1/2 inch, 1 inch, 3/4 inch, 1/2 inch, 3/8 inch, No. 4 and No. 8 (37.5 mm, 25.0 mm, 19.0 mm, 12.5 mm, 9.5 mm, 4.75 mm, and 2.36 mm).
(e) Field scale, 70 lb (40 kg) capacity, and 0.1 lb (0.1 kg) sensitivity.
(f) Drying equipment, hot plate or oven with tins.
(g) Speedy Moisture Tester, 26 gram size. If approved electronic probes are used, the Speedy Moisture Tester requirement may be waived.
(h) Sample splitter (riffle type).

3.1.3.1.2 The following test equipment shall be furnished on all projects calling for 10 yd^3 (7.5 m^3) or greater of concrete unless specifically waived:

(a) Slump test set, (AASHTO T 119)
(b) Air-Entrainment Meter (AASHTO T 152, Type B)
(c) Curing box for concrete cylinders*
(d) Scoop and squared trowel, minimum 6 inch (150 mm) blade.
On projects with more than 100 CY (75 m3) of concrete, the following additional test equipment will also be required:
(e) Scale, minimum 70 lb (40 kg) capacity, 0.1 lb (0.1 kg) sensitivity
(f) Steel "contractor's" wheelbarrow
(g) Hoe and hand shovel
(h) Ten foot (three meter) metal straightedge
(i) Microwave oven, 700 watt, 120 volt, 60 hertz, minimum 1.3 ft3 (0.04 m3), variable power from 10 to 100 percent. (j) A scale, minimum capacity of weighing a 5 kilogram sample, 1.0 gram sensitivity.

* On projects with less than a total of 100 yd^3 (75 m^3) of concrete, the curing box shall be relatively airtight with provisions for storing cylinders in damp sand or sawdust at temperatures between 60º F (16º C) and 80º F (27º C). On projects with more than 100 yd^3 (75 m^3) of concrete, the curing box shall comply with the following specifications:

The internal dimensions shall be approximately 30 inch long by 18 inch wide by 19 inch deep (760 mm long by 460 mm wide by 480 mm deep). The top shall be hinged at the back and a lock shall be provided at the front. The interior shall be rustproof. A moisture-proof seal shall be provided between the lid and the box.

A drain pipe shall be provided through the side of the box. A grating shall be provided to hold the concrete cylinders above the water surface.

A minimum/maximum thermometer shall be installed to measure the internal temperature of the box. The thermometer shall be readable from outside of the box and shall be accurate to within 2 °F (1 °C). The thermometer shall have minimum graduations of 2 °F (1 °C). A thermostat shall maintain the water at a temperature of 72 ± 5 °F (22 ± 3 °C) when the ambient temperature is as low as -10 °F (-23 °C).

3.1.3.1.3 When concrete is placed at more than one location simultaneously, the necessary testing equipment shall be furnished at each location.

3.1.3.1.4 Testing equipment shall be calibrated by the Contractor in accordance with 106.03.

3.1.3.2 Performance Requirements (QC/QA)

3.1.3.2.1 The following test equipment shall be furnished on all projects calling for 10 yd^3 (7.5 m^3) or greater of concrete unless specifically waived:

(a) Slump test set, (AASHTO T 119)
(b) 2 Air-Entrainment Meters (AASHTO T 152, Type B)
(c) Curing box for concrete cylinders
Provide a sufficient number of boxes to hold all the required number of concrete test cylinders for a minimum period of 48 hours.
(d) Scoop and squared trowel, minimum 6 inch (150 mm) blade.

On projects with more than 100 yd^3 (75 m^3) of concrete, the following additional test equipment will also be required:

(e) Scale, minimum 70 lb (40 kg) capacity, 0.1 lb (0.1 kg) sensitivity
(f) Steel "contractor's" wheelbarrow
(g) Hoe and hand shovel
(h) Ten foot (three meter) metal straightedge
(i) Microwave oven, 700 watt, 120 volt, 60 hertz, minimum 1.3 ft^3 (0.04 m^3), variable power from 10 to 100 percent. (Provide 2 for QC/QA)
(j) A scale, minimum capacity of weighing a 5 kilogram sample, 1.0 gram sensitivity.
(k) Sufficient number of microwave safe dishes.

3.1.3.2.3 When concrete is placed at more than one location simultaneously, the necessary testing equipment shall be furnished at each location.

3.1.3.2.4 Testing equipment shall be calibrated by the Contractor in accordance with 106.03.

3.1.4 Consistency.

3.1.4.1 Method Requirements

3.1.4.1.2 Mortar proportions shall be kept to the lowest that will provide the desired workability. Mixing water shall be kept to the minimum that will produce the required consistency as measured in accordance with AASHTO T 119, as modified in 3.1.6, and does not exceed the water/cement ratio established by Table 1A unless authorized by the Engineer. Slumps shall be kept within the following limits unless otherwise permitted:

Footings and mass concrete	2 - 4 inch	(25 - 75 mm)
Columns and pedestals	2 - 4 inch	(50 - 100 mm)
Decks and sidewalks	2 - 4 inch	(50 - 75 mm)
Tremie concrete	6 - 8 inch	(150 - 200 mm)
Walls over 18 inch (460 mm) thick	2 - 4 inch	(50 - 75 mm)
Walls 18 inch (460 mm) thick and under	2 - 4 inch	(50 - 100 mm)
Concrete with High Range Water Reducer	8 inch maximum	(125 - 175 mm) maximum

3.1.5 Air-Entrainment.

3.1.5.1 Air-entrainment of the required percentage shall be obtained by the use of air-entraining admixture unless otherwise permitted. Air content will be determined in accordance with AASHTO T 152, except as modified in 3.1.6.1.

3.1.5.2 The percentage of air-entrainment for pumped concrete shall be taken at the discharge end of the pump line.

3.1.6 Testing.

3.1.6.1 Method Requirements.

3.1.6.1.1 Test cylinders shall be made in accordance with AASHTO T 141 except that the entire sample for test cylinders and testing air-entrainment and slump may be taken at one time from the middle of the batch. Errors in proportioning or mixing as evidenced by excessive slump will be cause for rejection. Cylinders shall be made and cured in accordance with AASHTO T 23. To determine compliance with Table 1A, cylinders shall be tested in accordance with AASHTO T 22 and the test strength shall be the average compressive strength of at least two cylinders tested at the end of the 28 day curing period.

3.1.6.1.1.1 For concrete class F, flowable fill cylinders for compressive strength tests will be prepared when required in accordance with ASTM D 4832 as modified by NHDOT Test Procedure P-2.

3.1.6.1.2 When ordered by the Engineer, mixes will be reviewed for use by test samples of at least 5 yd^3 (4 m^3) a minimum of 14 days prior to use on the project. Tests for water/cement ratio, air content and final slump on fresh concrete at maximum delivery time shall be performed. Cylinders for testing strength and permeability will be made and tested by the Department, if required. Tests of workability and finishing characteristics as well as any other test deemed necessary will be performed. Payment for test samples will be per 109.04.

3.1.6.1.3 Unit weight shall be determined in accordance with AASHTO T 121.

3.1.6.2 Performance Requirements (QC)

3.1.6.2.1 The Contractor shall administer an approved Process Quality Control Plan for each QC/QA Concrete class specified, hereinafter referred to as the "Plan", sufficient to ensure a product which meets the contract requirements. The Plan shall meet the requirements of 106.03.1.

3.1.6.2.1.1 The Plan shall address all elements which affect the quality of the structural concrete including, but not limited to, the following:

(a) Mix Design(s); including aggregate source and gradations
(b) Concrete Supplier and Plant Location
(c) Quality of Components
(d) Stockpile Management
(e) QC Inspection Activities
(f) QC Testing and Inspection Report Forms and Process for Department Submittal
(g) Process Quality Control Testing: include details for frequency, location and sampling methods for slump, air content, water content, temperature, and evaporation rate.
(h) Placement Method(s) and Consolidation including proposed backup equipment.
(i) Proposed Finishing Machines
(j) Evaporation Control Procedures
(k) Finishing and Curing Methods
(l) Version of the Specification to be used.

3.1.6.2.1.2 The Plan shall include the following personnel performing the described functions and meeting the following minimum requirements and qualifications:

a) **Plan Administrator** meeting one of the following qualifications:

Prior to April 1, 2008:

1) Professional Engineer registered in the State of NH with one year of highway experience acceptable to the Department.
2) Engineer-In-Training certified by the State of NH with two years of highway experience acceptable to the Department.
3) An individual with three years highway experience acceptable to the Department and with a Bachelor of Science Degree in Civil Engineering Technology or Construction.

After April 1, 2008:

Certification as NETTCP QA Technologist will be required for Plan Administrators

b) Process Control Technician(s) (PCT) shall utilize test results and other quality control practices to ensure the quality of aggregates and other mix components and control proportioning to meet the mix design(s). The Plan shall detail the frequency of sampling and testing, corrective actions to be taken, and documentation. The PCT shall periodically inspect all equipment utilized in proportioning and mixing to ensure it is operating properly and that proportioning and mixing conforms with the mix design(s) and other contract requirements. The Plan shall detail how these duties and responsibilities are to be accomplished and documented and whether more than one PCT is required. The Plan shall include the criteria utilized by the PCT to correct or reject unsatisfactory materials. The PCT shall be a New England Transportation Technician Certification Program Concrete Technician Level I or be a Construction Materials Technician Trainee under direct observation of a New England Transportation Technician Certification Program Concrete Technician Level I

c) Quality Control Technician(s) (QCT) shall perform and utilize quality control tests at the job site to ensure that delivered materials meet the requirements of the mix design(s), including

temperature, water/cement ratio, air content, and strength. The QCT shall inspect all equipment utilized in transporting, placing, consolidating, finishing, and curing to ensure it is operating properly and that placement, consolidation, finishing, and curing conform with the contract requirements. The Plan shall detail frequency of sampling and testing, corrective actions to be taken, and documentation. The Plan shall detail how these duties and responsibilities are to be accomplished and documented, and whether more than one QCT is required. The Plan shall include the criteria utilized by the QCT to reject unsatisfactory materials. The QCT shall meet the same qualifications as the PCT.

3.1.6.2.1.3 The Plan shall detail the coordination of the activities of the Plan Administrator, the PCT and the QCT.

3.1.6.2.1.4 The Contractor shall provide a Delivery Record for each truck load of concrete. The Delivery Record shall include:

Contract Name & Number
Bridge Number
Manufacturing Plant (Batching Facility)
Name of Contractor (Prime Contractor)
Date
Time Batched/Time Discharged
Truck Number
Load Number
Quantity (Quantity Batched this Load)
Target Weights Per cubic yard (cubic meter) and Actual Batched Weights for:

1. Cement
2. Supplemental cementitious materials - Fly Ash, Ground Granulated Blast Furnace Slag and/or Silica Fume
3. Coarse Aggregate
4. Fine Aggregate
5. Water (including water added at the batch plant and at the project site)
6. Air-Entraining, Water Reducing and/or other Admixtures including brand, type, and quantity.
7. Aggregate Moisture (Percent)

The Delivery Record shall be signed by a Process Control Technician affirming the accuracy of the information provided.

3.1.6.2.1.5 Concrete placed shall be sampled, tested, and evaluated by the Contractor in accordance with the minimum process quality control requirements in Table 6:

Table 6 - Minimum Process Quality Control Requirements Class AA

PROPERTY	TEST FREQUENCY	TEST METHOD
Slump	First 3 Loads per Pour Per Class of Mix Then as Needed to Control Operations, or When Visual Change in Mix or Change on the Certificate of Compliance	AASHTO T119
Air Content		AASHTO T152
Temperature		ASTM C 1064
Strength	As Needed to Control Operations	AASHTO T22 & 23
Water Content	As Needed to Control Operations	Per Approved Plan
Evaporation Rate[1]	Once per sublot	Per Appendix B

[1] For Concrete Class AA used in bridge decks and at grade approach slabs only.

Table 6a - Minimum Process Quality Control Requirements Class A and B

PROPERTY	TEST FREQUENCY	TEST METHOD
Slump	As Needed to Control Operations	AASHTO T119
Air Content	As Needed to Control Operations	AASHTO T152
Temperature	As Needed to Control Operations	ASTM C 1064
Strength	As Needed to Control Operations	AASHTO T22 & 23
Water Content	As Needed to Control Operations	Per Approved Plan

3.1.6.2.1.5.1 Water content will be controlled by a method proposed in the plan and approved by the Engineer. Concrete not meeting the plan minimum requirements for air content shall not be incorporated in the work.

3.1.6.3 Performance Requirements - Quality Assurance (QA)

3.1.6.3.1 Structural concrete designated for acceptance under Quality Assurance (QA) provisions will be sampled once per sublot on a statistically random basis. Samples will not be taken until the Contractor has accepted the material for placement. Samples will be obtained in accordance with AASHTO T 141 as amended in 3.1.6.3.3 and will be tested and evaluated by the Department in accordance with 106.03.2 and the acceptance testing schedule in Table 7:

Table 7 - Acceptance Testing Schedule

PROPERTY	SUBLOT SIZE	TEST METHOD
Strength	See 520.3.1.7.2.1	AASHTO T 22 & 23
Permeability	See 520.3.1.7.2.1	AASHTO T 277
Air Content	See 520.3.1.7.2.1	AASHTO T 152
Water/Cement Ratio	See 520.3.1.7.2.1	NHDOT Microwave
Concrete Cover	Each Data Point	Rebar Depth Measuring Unit See 520.3.1.7.3.3

3.1.6.3.2 Lot Size. For the purpose of evaluating all acceptance test properties, a lot for Class A and B shall consist of the total quantity represented by each QC/QA Concrete item mix design. On contracts which include multiple structures a lot shall consist of the total quantity represented by each QC/QA Concrete item mix design for each structure. Each structure will be evaluated as a separate lot. The unit price for each QC/QA item will be determined per 5.8.1 for each structure. A lot for Class AA shall be a day's placement. A day's placement will be defined as all concrete placed on the same day or a continuous placement occurring over two or more days. For a lot to be evaluated for pay adjustment, it must have at least three sublots.

3.1.6.3.2.1 Sublot Size. The following schedule will determine the number and size of sublots for a days placement.

Table 4 - Class A and B Number and Size of Sublots

DAYS PLACEMENT PER QC/QA CONCRETE ITEM	NUMBER OF SUBLOTS
0 to 50 CY inclusive (0 to 40 m^3 inclusive)	1
>50 to 150 CY inclusive (40 to 115 m^3 inclusive)	2 split equally
>150 to 300 CY inclusive (115 to 230 m^3 inclusive)	3 split equally
Over 300 CY (Over 230 m^3)	split equally [1]

[1] Sublots shall be greater than or equal to 100 cubic yards (75 m^3) and less than 135 CY (100 m^3).

3.1.6.3.2.2 Sublot Size for Class AA. A sublot for Class AA shall typically be 50 cy (40 $m^{3)}$. Lots less than 175 cy (135 m^3) shall be split equally into three equal sublots. A day's placement of less than 50 cy (40 m^3) shall be tested as a sublot of the previous lot (if there is no previous lot it shall be a sublot of the subsequent lot). The last sublot shall be greater than or equal to 25 cy (20 m^3) and less than 75 cy (60 m^3).

3.1.6.3.2.3 Sublot Size for Class A and B. If a QC/QA Class A or B concrete item cannot be evaluated with at least three sublots using the above Table 8, then the engineer's estimate of the total quantity for that QC/QA concrete item will be split equally into three sublots.

3.1.6.3.3 When concrete is placed by pumping, samples will be taken at the discharge end of the pump.

3.1.6.3.4 Rapid Chloride Permeability. Rapid Chloride Permeability test will be conducted on samples obtained by the Bureau of Materials & Research and performed in accordance with AASHTO T 277 at an age of 56 days or later. Samples for all placements for Class AA and for all placements for Class A will be cut from the middle half of 4 in x 8 in (100 x 200 mm) cylinders. One sample will be taken per sublot placed, with no less than three samples per lot. When concrete is specified to contain a corrosion inhibitor containing calcium nitrite, permeability testing will not be done and the pay factor for this concrete will be 1.0.

3.1.6.3.5 Water Cement Ratio. Water Cement Ratio shall be determined using the New Hampshire Department of Transportation microwave method as described in Appendix A of Section 520 contained in this special provision.

3.1.6.3.6 Concrete Cover. Concrete cover over reinforcing steel will be evaluated by the Bureau of Materials and Research. The Contractor shall give three working days notice to the Bureau of Materials and Research of the availability of the concrete section to be measured. A date will be scheduled to measure the cover. Prior to measurement, the Engineer, will provide locations for the measurements to be taken. The Contractor shall be responsible for marking the layout for rebar cover measurement and shall ensure adequate accessibility for measurement apparatus on the concrete section to be measured on the date scheduled. Concrete cover over reinforcing steel will be evaluated as follows:

a) **Bridge Decks.** Concrete cover will be determined with a GSSI SIR2 radar rebar depth measuring unit. A run of measurements will be taken parallel to the centerline within each lane over 10 feet (3 meters) wide. A hole for calibration shall be taken for each placement. A depth verification hole shall be taken for each run. Coping areas, backwalls and areas on the deck where the top and bottom of the deck are not parallel or where the angle at the crown is changing will not be evaluated for cover.
b) **Pedestrian sidewalks.** Concrete cover will be determined with GSSI SIR2 radar rebar depth measuring unit. A run of measurements will be taken along the centerline of the sidewalk. One hole will be taken for depth calibration. Concrete in the sidewalks will be evaluated as a separate lot for cover
c) **At Grade Approach Slabs.** Concrete cover will be determined with a GSSI SIR2 radar rebar depth measuring unit. A run of measurements will be taken parallel to the centerline within each lane over 10 feet (3 meters) wide. A depth verification hole will be taken for each run for calibration.
d) **Rail support slabs**. Concrete cover will be determined with GSSI SIR2 radar rebar depth measuring unit. A run of measurements will be taken parallel to the curb line, offset 1'-6" towards the roadway edge of the slab. A depth verification hole will be taken for each run for calibration.

3.1.6.3.7 Evaluation of materials will be made using the specification limits in Table 1B.

3.1.6.3.7.1 Concrete produced in accordance with a Contractor-provided mix design which fails to meet the specified compressive strength at 28 days, based on the average of two concrete cylinders per sublot, will be evaluated by comparison of the actual compressive strength (f 'ca) with the specified compressive strength (f 'c) as follows:

1. If (f 'c– f 'ca) is less than 60 psi (400 kPa), the concrete will be accepted as being in conformance and no pay adjustment shall apply.
2. If the (f 'c- f 'ca) value is between 60 and 500 psi (400 kPa and 3500 kPa) the Engineer may:
   a) Require corrective action at no additional expense to the Department; or
   b) Accept the concrete with a calculated pay adjustment as described in 5.9.2.
3. If the (f 'c- f 'ca) value is greater than 500 psi (3500 kPa), the lot will be rejected and subject to the provisions of 106.03.2.2.

3.1.6.3.7.2 On bridge decks, approach slabs and rail support slabs, when the average actual concrete cover over the top bar of the top mat of the reinforcing steel is less than the lower specification limit, the Contractor shall correct the deficiency. A plan to correct the deficiency shall be submitted to the Engineer for review and acceptance prior to performing any work. An acceptable plan could include, but not be limited to, grinding the surface and applying a concrete overlay.

When the average concrete cover over the reinforcing steel is greater than the upper specification limit corrective action may be required.

3.1.6.3.7.3 Concrete placement operations may be suspended when the pay factor of any property for a lot, as determined in accordance with 106.03.2.4:

1. Drops below 1.00 and the Contractor is taking no corrective action, or
2. Is less than 0.90.

The placement operations shall not resume until the Engineer determines that material meeting the contract requirements can be produced.

3.2 Forms and Falsework.

3.2.1 Drawings and data for falsework shall be submitted for documentation in accordance with 105.02. A concrete density of 150 lb/ft^3 (2,400 kg/m^3) and a live load of 50 lb/ft^2 (245 kg/m^2) shall be used in calculations. Adequate provisions shall be made for the effect of vibration and impact on the forms and falsework.

3.2.2 Wood forms and bracing materials shall be of approved lumber, mortar tight, and free of imperfections on exposed surfaces. Forms shall have sufficient studs, walers, and stiffbacks to eliminate bulging and shrinking. Surfaces which will be exposed to view in the final structure shall be formed with plywood unless otherwise specified or permitted. Plywood which will not give a concrete finish essentially equal to new plywood shall not be used. All plywood shall be placed with the grain horizontal.

3.2.3 Forms shall be installed to the lines and grades shown on the plans or ordered. Forms for grade lines exposed to view such as top of curbs, walls, bearing areas, and the like, shall be cut to grade unless otherwise permitted. Wood in contact with the concrete shall be treated with an approved form release compound prior to erection. Cleaning and inspection ports shall be provided as ordered.

3.2.4 Ties and anchorages for use in forms above the top of footings shall be fabricated so as to be removed to a minimum depth of 2 inches (50 mm) without injury to the concrete.

3.2.5 Chamfer strips shall be installed as shown on the plans or ordered. Joints which are to receive external waterproofing shall not be chamfered.

3.2.6 Metal forms shall comply with the pertinent requirements of 3.2.2. Projections into the finished concrete surface will not be permitted. Connection devices shall hold the forms rigidly in alignment and shall be removed without injury to the concrete.

3.2.6.1 Forms made of other materials such as fiberglass or plastic may be used when permitted.

3.2.7 Falsework shall be placed on an approved solid footing or piling. Provisions shall be made for adjusting forms to grade and compensating for settlement during placement of concrete. Improper or inadequate bracing shall be satisfactorily corrected.

3.2.8 Stay-in-place deck forms shall not be used unless specifically allowed on the plans.

3.3 Weepers and Drains.

3.3.1 Four inch (one hundred millimeter) weepers at approximately 10 ft (3 m) on centers shall be placed at the elevations shown or ordered unless otherwise directed. Coarse gravel or stone shall be placed at the inlets and outlets to permit unobstructed flow of the weepers. An approved geotextile patch may be substituted on the inlet end of weepers in place of the coarse gravel or stone.

3.4 Ready-Mixed Concrete.

3.4.1 General.

3.4.1.1 Ready-mixed concrete is defined as portland cement concrete manufactured for delivery in a plastic state. It shall be in compliance with AASHTO M 157 or as modified herein.

3.4.1.2 Ready-mixed concrete shall be mixed and delivered to the point designated by means of one of the following combinations of operations:

(a) Central-mixed concrete. Mixed completely in a stationary mixer and delivered in a truck mixer operating at agitation speed.
(b) Shrink-mixed concrete. Mixed partially in a stationary mixer and the mixing completed in a truck mixer.
(c) Transit-mixed concrete. Mixed completely in a truck mixer.

3.4.1.3 Non-agitating equipment will not be permitted for transportation.

3.4.2 Mixers.

3.4.2.1 Each mixer shall have metal plate or plates attached in a prominent place by the manufacturer, plainly marked with the gross volume of the drum, the capacity of the drum or container in terms of the volume of mixed concrete, and the mixing and agitating speeds. The volume of mixed concrete shall not exceed 63 percent of the total volume of the drum or container when the concrete is in transit or shrink-mixed, or 80 percent of the total volume when the concrete is central-mixed. Stationary mixers shall be equipped with an acceptable timing device that will not permit the batch to be discharged until the specified mixing time has elapsed.

3.4.2.2 When loaded to capacity, all mixers shall be capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass, and of discharging the concrete with a satisfactory

degree of uniformity at a rate which will not inhibit the rate of placement required. The rate of discharge shall be governed by the speed of rotation and not by restrictions of the discharge opening.

3.4.2.3 Mixers will be subject to inspection as frequently as considered necessary. If found unfit to function properly, the mixers will be disapproved for use until correct operating conditions have been restored. The pickup and throw-over blades shall be replaced or repaired when they have become worn 1 inch (25 mm) or more below the original height of the manufacturer's design, or have become loose, broken, bent, scalloped, or otherwise damaged. Any accumulation of hardened concrete shall be removed.

3.4.2.4 The Engineer may make tests for consistency of individual samples at approximately the beginning, the midpoint, and the end of the load. If the concrete is not of uniform quality, the mixer shall not be used until the condition is corrected and the mixer has been reinspected and approved.

3.4.3 Mixing.

3.4.3.1 Mixers shall be operated within the limits of their capacity as specified in 3.4.2.1 or as designated by the manufacturer of the equipment, whichever is less, and shall not exceed the speed of rotation designated by the manufacturer.

3.4.3.1.1 When high range water reducing admixture is used, the mix shall be delivered with 2 yd^3 (1.5 m^3) less than the manufacturer's rated capacity for mixing as specified in 3.4.2.1.

3.4.3.2 When shrink-mixed or central-mixed concrete is used, mixing time shall be measured from the time all the solid material is in the drum. The batch shall be so charged that some water will enter in advance of the cement and aggregates and all water will be in the drum by the end of the first one fourth of the specified mixing time.

3.4.3.3 Where mixer performance tests have not been made, the minimum mixing time for mixers having capacities less than 1 yd^3 (0.8 m^3) shall be 1 minute. For mixers of greater capacity, the minimum mixing time shall be increased by 15 seconds for each cubic yard (cubic meter) of additional capacity or fraction thereof.

3.4.3.4 When shrink-mixed concrete is used, the mixing time in the stationary mixer shall be at least that required to intermingle the ingredients. After transfer to a truck mixer, mixing at mixing speed and turning at agitating speed will be required as specified in 3.4.3.5.

3.4.3.5 When transit-mixed concrete is used, mixing shall be performed at the site of the work unless otherwise permitted. If the required uniformity is not obtained within 100 revolutions of the mixer after all ingredients are in the drum, that mixer shall not be used until the condition is corrected. Additional revolutions of the mixer beyond the number found to produce the required uniformity shall be at agitating speed except as stated in 3.4.3.7.

3.4.3.6 The Contractor shall provide a delivery record for each truck load of concrete. The delivery record shall include but not be limited to: date, time batched/time discharged, quantity (quantity batched this load), actual batched weights of: cement, admixtures, water, aggregates and aggregate moisture (percent). Target weights or out of tolerance notification will also be given for each of the actual batched weights given on the delivery record.

3.4.3.7 Water shall not be added after the initial introduction of the mixing water to the batch except when the slump is unsatisfactory. Such additional water as necessary, up to the amount permitted in 1.2, may be added to bring the slump within the limits specified in 3.1.4. The drum shall then be

turned an additional 30 revolutions at mixing speed. Water shall not be added at any later time unless permitted.

3.4.3.8 Mixing shall begin within the 30 minute period after the cement has been added to the aggregates unless otherwise permitted.

3.4.3.9 When pumps are used, truck mixers shall be scheduled and adjusted to the capabilities of the pumping units and the rate of placement to provide continuous pumping without excessive waiting time before discharge. Whenever possible, pumps shall be placed so that 2 trucks may discharge into the pump hopper at the same time. Actual discharge shall be such that the last of the load of one is discharged into the hopper with the beginning portion of the other.

3.4.3.10 Additional high range water reducing admixture, not to exceed the manufacturer's recommendation, may be required to be added at the project to reach slump requirements.

3.5 Placing Concrete.

3.5.1 General.

3.5.1.1 The Contractor shall notify the Engineer at least three working days in advance of each concrete placement to allow sufficient time to schedule required inspection and testing. A pre-pour conference shall be mandatory prior to any deck placement.

3.5.1.2 Concrete shall not be placed without inspection. Concrete so placed will be removed at the Contractor's expense unless authorized by the Engineer.

3.5.1.3 Approval will be required for alignment and grade, formwork and bracing, reinforcing steel and other inclusions, and the cleanliness of the forms prior to placing concrete.

3.5.1.4 If the Contractor proposes to place concrete by pumping, a detailed plan outlining his proposed method of operation shall be furnished along with a list of the pumping units proposed, the manufacturer's specifications and capabilities of the units, slickline diameter and maximum length of same, diameter and length of any flexible lines proposed, and the allowable continuous pumping pressure of each unit. This information shall be furnished seven days in advance of the scheduled operation to permit study of the equipment and methods proposed and the satisfactory resolution of any questions arising.

3.5.2 Equipment.

3.5.2.1 All equipment used in placing concrete shall be approved for the particular use intended. Equipment which will be in contact with the fresh concrete shall be mortar-tight and free of caked-on mortar and other contaminants. If other methods are not satisfactory, sandblasting will be required for cleaning.

3.5.2.2 Crane buckets for placing concrete shall be low-slump type unless otherwise permitted.

3.5.2.3 Chutes, when permitted, shall be of approved materials and installed so as to prevent segregation. Any sign of segregation will result in rejection of chuting and utilization of an alternate approved method of placement.

3.5.2.4 Aluminum shall not be used in any equipment where it would be in contact with the fresh concrete.

3.5.2.5 When pumping concrete, the number and lengths of flexible lines shall be kept to the minimum required for distribution. Transition sections used to reduce the diameter of lines shall be of slickline material and shall be as long as possible.

3.5.3 Placing.

3.5.3.1 General

3.5.3.1.1 Concrete shall be placed in its final location as soon as possible after mixing. Segregation of the mix or displacement of materials inside the forms will not be permitted.

3.5.3.1.2 Concrete shall be placed in layers not to exceed 12 inch (300 mm) and placing intervals shall not exceed 30 minutes unless otherwise permitted. Concrete which has attained a partial set shall not be used.

3.5.3.1.2.1 When placing deck concrete, concrete shall not be placed more than 10 ft (3 m) ahead of the finishing machine.

3.5.3.1.3 In the event of unscheduled stoppage of the work, vertical bulkheads shall be installed to ensure a minimum depth of 6 inch (150 mm) of concrete in the next lift of concrete when placement is resumed. See 3.6.2 also.

3.5.3.1.4 Care shall be taken to keep the concrete pressure on ties and forms within the design limits. Concrete shall not be dropped a distance of more than 5 ft (1.5 m) unless contained within a tremie, elephant trunk, or other approved system.

3.5.3.1.5 Concrete which has attained its initial set shall not be disturbed by personnel, equipment, or other construction operations for a minimum period of 72 hours unless otherwise permitted.

3.5.3.1.6 Defective sections of concrete shall be removed and replaced or repaired as directed.

3.5.3.1.7 Means to contain concrete class F, flowable fill within a designated space shall be provided. Approved methods to prevent pipes from floating during placement of concrete shall be used.

3.5.3.1.8 For earthen backfill operations or vehicle traffic for paving operations, concrete class F, flowable fill shall be left undisturbed until the material obtains sufficient strength to support the weight of foot traffic without deformation.

3.5.3.1.9 When concrete is to be placed against granite bridge curb; the granite curb shall have been kept continuously wet for a period of 12 hours before coming into contact with the fresh concrete. Care shall be taken when removing soaking material to ensure that the curbing remains wet until the fresh concrete is placed against it. Any standing water shall be removed before the concrete is placed.

3.5.3.1.10 When concrete is to be placed against any precast concrete member, the precast concrete member shall have been kept continuously wet for a period of 3 hours before coming into contact with the fresh concrete. Care shall be taken when removing soaking material to ensure that the member remains wet until the fresh concrete is placed against it. Any standing water shall be removed before the concrete is placed.

3.5.3.2 Method Requirements.

3.5.3.2.1 Any concrete that is not in place 1-1/2 hours after the cement has been added to the aggregates shall not be used unless otherwise permitted

3.5.3.3 Performance Requirements (QC/QA).

3.5.3.3.1 Concrete Class AA shall be placed to meet the following conditions for evaporation rates. Charts are given in Appendix B.

1. Evaporation rate shall not exceed 0.2 lb./sq ft/hr (1.0 kg/sq.-m/hr) for concrete with a water/cement ratio higher than 0.440.
2. Evaporation rate shall not exceed 0.1 lb./sq ft/hr (0.5 kg/sq.-m/hr) for concrete with a water/cement ratio 0.440 or under.

3.5.4 Consolidation.

3.5.4.1 Unless otherwise permitted, consolidation of all concrete shall be achieved by the use of approved internal vibrators with a frequency range of 7,000 to 10,000 impulses per minute. Vibrators used in concrete containing epoxy coated reinforcing steel shall be equipped with a non-metallic or non-metallic-coated head. Concrete shall not be moved excessive distances by the use of vibrators.

3.5.4.2 Vibrators shall be inserted vertically into the fresh concrete and withdrawn slowly. Vibration shall continue until consolidation is achieved and stopped before segregation occurs or water is forced to exterior concrete surfaces in appreciable amounts.

3.5.4.3 Concrete shall not be placed at a rate greater than that which can be thoroughly consolidated by the vibrators in use. The number of vibrators required will be based on the maximum predicted rate of placement. At least one reserve vibrator shall be furnished.

3.5.4.4 No consolidation or vibration of concrete class F, flowable fill is required.

3.5.5 Depositing Concrete Under Water.

3.5.5.1 Unless otherwise specifically permitted, all concrete placed in water shall be placed by tremie. Slump shall comply with 3.1.4.

3.5.5.1.1 Pumping for underwater placement of concrete shall also be into a tremie unless specific permission is given for direct placement by pump lines. Placement by direct pumping, if permitted, will require the hose to be securely fastened to the cofferdam frame at all times to eliminate surging of the hose in the concrete. If at any time the procedure becomes unacceptable, the remainder of the concrete shall be placed by a tremie. Tremie equipment shall be available on site prior to start of pumping operations.

3.5.5.2 A tremie shall consist of a watertight tube attached to a hopper of approved size with an adequate working space provided around the hopper. The tremie shall be attached to a crane or other approved hoisting equipment to permit lifting and lowering the tremie with sufficient rapidity to control and stop the flow of concrete as required. The equipment shall be capable of moving the tremie over the entire surface of the placement area.

3.5.5.3 At the start of placing operations, and at any time thereafter that the tremie is withdrawn from the concrete, an approved watertight plug shall be inserted into the discharge end of the tremie. The tremie shall be lowered until it rests on the bottom or in freshly deposited concrete. It shall then be checked for leaks. If watertight, the tremie tube and hopper shall immediately be filled with concrete. The hoisting mechanism shall then raise up the tremie to permit the discharge of the concrete without removal from freshly deposited concrete. The tremie shall then be lowered to stop the flow of concrete before it has dropped below the level of the bottom of the hopper. The hopper shall again be filled and

the process repeated until the desired intermediate or final grade is attained. Top concrete surfaces shall be approximately horizontal.

3.5.5.4 Concrete foundation seals shall be placed as shown on the plans or ordered. The elevation of the top of the seal and the required depth may need to be determined after the excavation is completed.

3.5.5.5 Test cores of approximately 2 inch (50 mm) diameter shall be taken by the Contractor through all concrete deposited underwater on rock. The cores shall penetrate a minimum of 1 ft (300 mm) into the rock. One core shall be taken near each corner and one shall be taken near the center. Should evidence of voids, seams or unsatisfactory concrete be discovered, additional cores shall be taken as ordered. Unsatisfactory material shall be removed and replaced or repaired as directed.

3.5.6 Substructure.

3.5.6.1 All substructure concrete shall be placed in the dry unless otherwise permitted. Footings shall be placed at the elevations shown on the plans or ordered.

3.5.7 Superstructure.

3.5.7.1 Compliance with superstructure concrete placing sequences shown on the plans will be mandatory unless prior approval is secured for an alternate sequence. If a pouring sequence is not shown, the Contractor shall submit his proposed pouring sequence for approval. Sufficient concrete placing units shall be furnished to maintain plasticity requirements. If there are multiple placements there shall be more than 72 hours between placements.

3.5.7.2 Concrete operations on steel structures shall not start until all temporary falsework and bracing have been removed unless otherwise permitted.

3.5.8 Bridge Deck Overlays.

3.5.8.1 Surface Preparation. The concrete deck shall be clean and free of laitance, oil, surface moisture, membrane residue, and other foreign materials. Abrasive blast cleaning may be required by the Engineer to achieve a suitable surface.

3.5.8.2 Placing Bridge Deck Overlays.

3.5.8.2.1 Prior to placing of concrete the clean surface shall be thoroughly coated with bonding grout conforming to 2.9.2 herein.

3.5.8.2.1.1 Care shall be exercised to ensure that all prepared surface areas receive a thorough, even coating, and that no excess bonding grout be permitted to collect in pockets.

3.5.8.2.1.2 The grouting operation shall not advance more than 3 to 5 feet (1 to 2 meters) ahead of the placing of concrete, but not more than 10 minutes ahead of the finishing machine, unless otherwise directed. Concrete shall be placed while the slurry remains wet. Areas that have dried shall be thoroughly cleaned of all dry slurry and slurry shall be reapplied.

3.5.8.2.1.3 Bonding grout that has dried, or become unworkable, as determined by the Engineer, shall not be incorporated in the work. No tempering will be permitted.

3.5.8.2.2 Concrete placed in patches more than 1 inch deep shall be hand vibrated internally in addition to the surface vibration provided by the finishing machine.

3.5.8.2.3 At transverse and longitudinal joints, the overlay course previously placed shall be sawn to a straight and vertical edge before the adjacent overlay course is placed.

3.5.8.2.4 Bridge deck overlays shall not be placed when air or deck temperature is below 45 °F (7 °C). Decks may be placed when these temperatures are 45 °F (7 °C) and rising temperature is predicted.

3.5.8.2.5 A construction dam or bulkhead shall be installed in case of major delay in the placement operation. During minor delays of one hour or less, the end of the placement may be protected from drying with several layers of wet burlap.

3.5.8.2.6 Adequate precautions shall be taken to protect freshly placed concrete from sudden or unexpected rain. The Engineer may order removal of any material damaged by rainfall.

3.5.8.3 Consolidation of bridge deck overlays shall be performed after the concrete has been screeded by the use of a separate, variable-speed vibrating pan attached to the finishing machine. Vibration shall be continuous until consolidation is achieved and stopped before segregation occurs or water is forced to exterior surfaces in appreciable amounts.

3.5.8.3.1 Concrete shall not be placed at a rate greater than that which can be thoroughly consolidated by the vibrator in use.

3.5.8.3.2 Hand vibrators shall be used adjacent to curbing and expansion joints whenever the machine vibrators cannot reach the areas.

3.5.8.4 Curing of bridge deck overlays shall meet the requirements of 520.3.10.1 curing method "c". At temperatures below 55 °F (15 °C), the Engineer may require a longer curing period.

3.5.8.4.1 Bridges may be opened to automobile traffic only after an initial curing, provided the required curing period has elapsed for all previously placed concrete patches.

3.5.9 Box Culverts.

3.5.9.1 Construction Joints shown on the plans or permitted shall be perpendicular to the base slab and normal to the culvert axis. Weepers and drains shall comply with 3.3.

3.6 Joints.

3.6.1 General.

3.6.1.1 All joints not exposed to view in the final structure shall be waterproofed in accordance with 538.

3.6.2 Construction and Contraction Joints.

3.6.2.1 Joints shown on the plans or permitted shall be keyed, doweled, or both as shown or directed. Sizes and spacings shall be as shown or ordered. Horizontal joints will not be permitted unless shown on the plans or occasioned by breakdown of plant or equipment in which case, in addition to 3.5.3.1.3, planed lumber shall be inserted into the fresh concrete to produce a horizontal line in surfaces which will be exposed to view.

3.6.2.2 When fresh concrete is to be bonded to previously place concrete, the abutting surface shall be abraded by sandblasting and cleaned by compressed air. Immediately prior to placing concrete, the abutting surface shall be saturated with water meeting the requirements of 2.5.

3.6.2.3 Where bonding is not desired, the existing concrete shall be coated with an approved form release compound before the adjacent concrete is placed.

3.6.3 Expansion Joints.

3.6.3.1 Expansion joints shall be constructed at the locations shown and in conformity with the details shown on the plans or ordered.

3.6.3.2 Open joints shall be formed at the locations shown on the plans. Inserts shall be fabricated so as to permit removal without damage to the work.

3.7 Concreting in Cold Weather.

3.7.1 General.

3.7.1.1 When the average daily temperature falls below 35 °F (2 °C) for more than 1 day, protective measures shall be taken to prevent damage to the concrete by freezing. The Contractor shall submit his proposed protective methods for approval. Concrete shall be protected from freezing for a minimum of 5 days. Concrete bridge decks shall not be placed without written permission.

3.7.2 Insulation.

3.7.2.1 Insulation shall be approved blanket, batt or board insulation with a thermal conductivity of less than 0.25 BTU per hour per square foot (0.8 W/m^2) for a thermal gradient of 1 °F/inch (0.02 °C/mm).

3.7.2.2 Concrete delivery temperature shall be 50 to 70 °F (10 to 20 °C) for sections 24 inch (600 mm) or less in thickness and 40 to 55 °F (5 to 15 °C) for sections thicker than 24 inch (600 mm) unless otherwise permitted.

3.7.3 Housing and Heating.

3.7.3.1 Housing for cold weather concreting shall consist of a framework covered with weathertight plastic or canvas and shall be large enough to completely enclose the work to be heated and to accommodate the required heating elements. Continuous maintenance and fire protection shall be provided.

3.7.3.2 Heaters shall be of approved type and shall be furnished in sufficient quantity to maintain the required temperature without creating hot spots in the concrete.

3.7.4 Concrete.

3.7.4.1 Concrete shall be brought to the required temperature by the use of heated mixing water or heated aggregates or both. The maximum allowable temperature of water shall be 160 °F (70 °C) and the maximum allowable temperature for aggregates shall be 100 °F (40 °C). The heated water shall be added to the aggregates prior to the addition of the cement.

3.7.4.2 Concrete delivery temperature shall be 50º to 70 °F (10º to 20 °C) for sections 24 inch (600 mm) or less in thickness and 40º to 55 °F (5º to 15 °C) for sections thicker than 24 inch (600 mm) unless otherwise permitted.

3.7.4.3 If the air temperature and transporting distance prevent the delivery of the concrete at the required temperature without exceeding the maximum allowable temperature in 3.7.4.1, the placement shall be canceled until such time as the requirements can be met.

3.7.4.4 Forms, reinforcing steel, existing concrete and all other materials which will be in contact with the fresh concrete shall be brought to a temperature of 50 °F (10 °C) and all frost shall be removed within the limits of the foundation prior to placing concrete.

3.7.4.5 Concrete shall be placed in the forms as soon as possible after delivery and as rapidly as possible without exceeding form and tie capacities. Tarpaulins or other approved materials shall be used to cover the top openings in forms to prevent heat loss. Only that portion of the form required for placement shall be opened and the opening shall be recovered between trucks unless otherwise permitted.

3.7.4.6 Finishing shall be completed as rapidly as possible. On areas where Item 534.3 is not used, liquid curing compound shall be applied to exposed surfaces immediately after finishing. After the concrete has set, plastic shall be placed over the exposed areas. When insulation is used, a covering of approved insulation or a layer of hay and a tarpaulin shall be placed over the plastic and secured in place.

3.7.4.7 The concrete temperature shall be maintained between 50º and 100 °F (10 º and 40 °C) for the first 72 hours and between 40º and 100 °F (4 º and 40 °C) for the next 48 hours. The concrete shall then be permitted to cool at a rate not to exceed 1 °F (0.5 °C) per hour until it reaches the atmospheric temperature.

3.7.4.8 During cold weather, cofferdams shall remain dewatered and the concrete kept from freezing for 24 hours following placing. After 24 hours, the Contractor may allow the cofferdam to flood.

3.8.1 General.

3.8.1.1 The Contractor shall maintain the as delivered concrete below 85 °F (30 °C). This may require the addition of ice to the mixing water, sprinkling the forms and reinforcing steel, scheduling the concrete placements for early morning or evening hours, or any other approved methods.

3.8.1.2 After placement, the concrete shall be maintained below 100 °F (40 °C) by sunshades, windscreen, fog spray, wet burlap, or other approved methods.

3.8.1.3 If excess water demand or too rapid setting is anticipated, a Water-Reducing or Retarding Admixture may be added to the mix in the amounts ordered.

3.8.1.4 When daytime air temperatures exceed 85 °F (30 °C), concrete temperature exceeds 80 °F (25 °C), and in the opinion of the Engineer, satisfactory surface finish cannot be achieved, nighttime or early morning placement may be required. No additional compensation will be allowed for this work.

3.9 Finishing Plastic Concrete.

3.9.1 Surfaces Other Than Decks and Approach Slabs (at grade).

3.9.1.1 All upper horizontal surfaces such as the top of wings, bearing pedestals, and the like shall be finished by placing an excess of material in the forms and screeding off the excess after consolidation. The surface shall then be finished by the use of wood, magnesium, cork, canvas floats, or steel trowels as directed.

3.9.1.2 Catwalks shall receive a magnesium float finish.

3.9.1.3 Sidewalks shall receive a broom finish by lightly dragging a broom transversely across the finished concrete to roughen the surface unless otherwise directed. Surfaces beneath bridge rail posts, light pole bases, and the like shall not be broomed.

3.9.1.4 All finishing shall be performed by persons experienced in the use of finishing equipment.

3.9.2 Concrete Decks and Approach Slabs (at grade).

3.9.2.1 All concrete decks shall be finished with the use of an approved self-propelled finishing machine with strike-off auger(s), capable of adjustment for crown and width, and capable of raising the screeds to clear the concrete when required unless specific written permission is given for an alternate method. Approach slabs (at grade) shall have the same finish requirements as concrete decks except that the finishing machine does not have to be self-propelled and equipped with auger(s).

3.9.2.2 Screed rails shall be set and checked for the finishing machine to ride on. The rails shall have sufficient rigidity and support to prevent deflection. After the rails are set, the finishing machine shall be placed on the rails and operated over the entire deck as many times as necessary to assure the required depth of concrete and the proper clearances to the reinforcing steel prior to starting the placement.

3.9.2.3 The finishing machine shall follow closely behind the placing and consolidating operation and the placing and finishing operations shall be continuous. See 3.5.3.1.2.1.

3.9.2.4 All work behind the finishing machine shall be performed from work-bridges. Work-bridges shall have independent movement capability and shall not be attached to the finishing machine. Walking in the concrete behind the finishing machine will not be permitted.

3.9.2.5 The finished concrete shall have the required crown and grade and the surface shall not vary from either by more than 1/8 inch in 10 ft (3 mm in 3 m). The surface shall have a concrete surface profile (CSP) of 5 or less in accordance with the International Concrete Repair Institute (ICRI) technical guideline for "Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays" Guideline No. 03732. As soon as the bleeding has stopped or the sheen has started to disappear, the concrete shall be given a final surface finish by scraping or dragging with an approved float at least 3 ft (1.0 m) in length. The float shall be placed on the outer edge of the finished concrete and moved transversely the full width of the deck. The finished edge shall be parallel to centerline. Each subsequent pass shall lap the preceding pass by at least 1/2 the length of the float. Concrete decks that will be the final wearing surface shall receive a pan drag without a float finish. This shall be followed by a broom finish utilizing a broom specifically made for this purpose. Fabric impressions in the surface caused by the texture of water-retaining materials shall not be cause for rejection. Objectionable defects, such as sharp edges caused by cement cream lines or fabric creases, shall be removed by the Contractor.

3.10 Curing Concrete.

3.10.1 All exposed surfaces of concrete, except Class F, Flowable Fill, shall be cured in accordance with the requirements of Table 9. All water used to wet cure concrete shall conform to 2.5. Failure to cure concrete by an approved method shall be cause for rejecting the work.

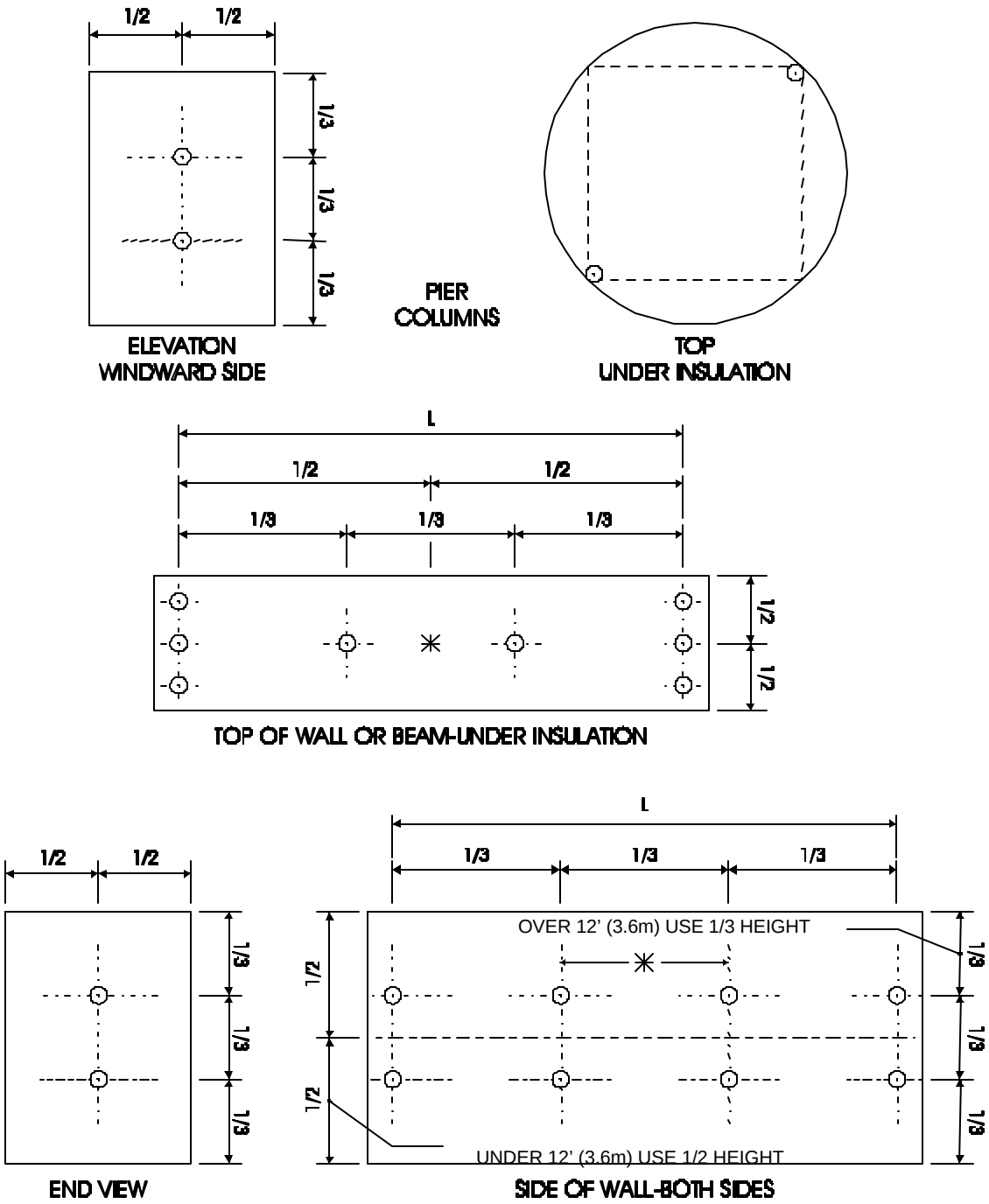
TABLE 9 - CONCRETE CURING

Type of Construction	Curing Method	Minimum Number of Days Before Membrane Application	
		Horizontal	Vertical
Bridge Decks, approach slabs and overlays	c	per Section 538	per Section 538
Concrete to be treated w/ Item 534 or 537	a		
All other concrete except Class F, Flowable Fill	a or b	14	7

Cure Method "a" - Concrete shall be kept moist until it can support curing covers at which time it shall be completely covered with a vapor-proof barrier conforming to 2.6.2. Water shall be reapplied as necessary to keep the surface of the concrete wet for the entire 7 day cure period.

Cure Method "b" - Immediately after finishing, all exposed surfaces shall be treated with a liquid curing compound conforming to 2.6.3 at the rate of 1 gallon per 200 square feet (2 liters per 10 square meters) or by fog spray, sprinkling or ponding of water conforming to 2.5 or any combination of the above, when the weather permits. Within 24 hours of finishing, these surfaces shall be completely covered with a vapor-proof barrier conforming to 2.6.2 for the remainder of the 7 days.

Cure Method "c" - The surface shall receive a wet cure utilizing water retaining material for at least 7 days. Water retaining material shall be burlap conforming to 2.6.1, cotton mats conforming to 2.6.4 or other approved water retaining material. Water retaining material shall be kept wet for the entire seven days. Apply water retaining material in accordance with 3.10.2. During the first 24 hours, the water retaining material shall be kept continuously wet by means of an approved automatic sprinkling or wetting system. After 24 hours, the Contractor may cover the wet water retaining material with a 4 mil (0.1 mm) minimum white polyethylene film for the remainder of the curing period in lieu of using a sprinkling or wetting system although wetting under the polyethylene may be required.



NOTE: WHEN "L" IS GREATER THAN 24 FEET (9 m), SPACING OF THERMOMETERS INDICATED BY (*) TO BE APPROXIMATELY 8 FEET (3 M) ON CENTERS LONGITUDINALLY.

THERMOMETER LOCATIONS

FIGURE 3
LOCATION OF THERMOMETERS

3.10.2 Application of Water Retaining Curing Material.

3.10.2.1 Burlap shall be applied damp within 30 minutes after concrete has been finished.

3.10.2.2 Unsized cotton mats shall be applied dry within 10 minutes after concrete is finished and saturated immediately after. Care shall be exercised to ensure that the cotton mats are weighted down adequately to provide continuous contact with the concrete surface.

3.10.2.3 Other approved water retaining curing material shall be applied in accordance with the manufacturer's recommendations and as approved by the Engineer.

3.11 Loading Concrete.

3.11.1 Removing Forms

3.11.1.1 Unless otherwise permitted, load bearing forms may not be removed until concrete test cylinders have attained 80 percent of the specified design compressive strength. If not controlled by such tests, the following periods may be used as a guide: For load bearing falsework, 14 days; for all other parts, 3 days or as directed. Non-load bearing forms may be removed in order to finish the concrete surface following a minimum 24 hours cure time, when directed by the Engineer.

3.11.1.2 The provisions of 3.10 shall apply if forms are removed prior to completion of the curing period.

3.11.2 Loading Restrictions.

3.11.2.1 Nothing, except as permitted in 3.10.1, shall be placed on the concrete prior to the minimum time periods specified in Table 10.

TABLE 10 - CONCRETE LOADING

Type of Construction	Minimum Requirements before Loading after Placement of Concrete
Substructure concrete including footings	80% of design strength or 7 days
Box culvert base slabs	5 days
Superstructure concrete	1,800 psi – (15 Mpa) for curb placement; 80% of design strength for light vehicular loads when permitted 3,200 psi – (20 Mpa) for membrane and paving placement; and 4,000 psi – (30 Mpa) for legal traffic loads.

3.11.2.2 The peak particle velocity ground vibration limits adjacent to newly placed concrete as specified in 203.3.2.5.1.5 shall apply.

3.12 Finishing.

3.12.1 General.

3.12.1.1 Surface finishes shall be classified as follows:

Class 1, Ordinary Finish
Class 2, Rubbed Finish

3.12.1.2. Forms may be removed in accordance with 3.11.1.1. If the required curing period has not been completed for a surface being finished, only the portion of the surface actually being finished shall be exposed, and curing will be immediately re-established once the phase of finishing underway has been completed.

All exposed concrete surfaces shall be given a Class 1, Ordinary Finish. If a Class 2 or other finish is required, it shall be as specified by the Plans, Supplemental Specifications, or Special Provisions for designated surfaces.

3.12.1.3 Class 1, ordinary finish. Fins and projections shall be removed from all surfaces except those which will not be exposed. On all exposed surfaces the cavities produced by form ties, honeycomb spots, broken corners or edges, and all other holes and defects shall be thoroughly cleaned and saturated with water for not less than 3 hours. These areas shall then be carefully pointed and trued with a mortar composed of the same brand of cement and fine aggregate mixed in the proportions of the concrete being finished. Mortar used in pointing shall not be more than 1 hour old. The mortar patches shall be cured as specified in 3.10. All expansion joints in the completed work shall be left carefully tooled and free of mortar. The joint fillers shall be left exposed for their full length with clean, true edges. Holes which will not be exposed may be filled with asphalt cement when permitted.

3.12.1.4 Class 2, rubbed finish. After removal of forms, holes and imperfections shall be filled with mortar conforming to 3.12.1.3. After the mortar has thoroughly set, the concrete shall be saturated with water for at least 3 hours. The concrete shall be kept continuously wet at all times during finishing. The surfaces shall then be rubbed with a medium coarse Carborundum stone and a small amount of mortar until all voids have been filled and all marks and projections have been removed and the surface is uniform. This surface shall be left until all concrete to be rubbed above it has been similarly treated.

3.12.1.4.1 After all concrete surfaces have received their initial rubbing, the next procedure shall consist of rubbing the concrete with fine Carborundum stone and water until a smooth uniform texture is obtained.

3.12.1.4.2 The final procedure shall consist of rubbing the concrete with dry burlap to remove loose powder. Should the final surface be unsatisfactory, a repetition of the above procedures will be required. The final surface shall have been achieved by altering the original concrete surface; a surface coating of cementitious material which adds thickness to the original surface is not acceptable.

3.12.1.5 All shrinkage cracks shall be treated as directed by the Engineer.

3.12.2 Method Requirements.

3.12.2.1 All copings shall receive a Class 2, Rubbed Finish. Exposed concrete surfaces containing imperfections shall be given a Class 2 finish or treated in some other manner approved by the Engineer. All other surfaces shall receive a Class 1 finish.

3.12.3 Performance Requirements (QC/QA).

3.12.3.1 All concrete copings and all other concrete surfaces shall receive a Class 1 finish unless otherwise specified.

Methods of Measurement

4.1 Concrete class AAA, AA, A, B, T and F will be measured by the cubic yard (cubic meter) in place unless otherwise indicated, and in accordance with the following.

4.1.1 Except as specified below, the volume will be computed to the nearest 0.1 cubic yard (cubic meter) by the prismoidal method using the dimensions as shown on the plans or as ordered. No allowance or measurements will be made for materials not entering permanently into the work or those used without proper authorization. No deductions will be made for the volume of concrete displaced by steel reinforcement, structural steel, expansion joint materials, scuppers, weepers, conduits, or the tops of piles.

4.1.1.1 Concrete Class T will be measured to the neat lines as shown on the plans. Seals on ledge will be measured to the ledge limit ordered to be removed.

4.1.1.2 When the Engineer determines that it is impracticable to measure the volume by dimensions, the volume will be based on the actual yield as determined in the field in accordance with AASHTO T 121.

4.1.1.3 Concrete Class B, footings (on rock) will be measured to the form lines placed at the limits shown on the plans. All concrete class B, footings (on rock) where rock will not be removed shall be formed and measured in accordance with 4.1.1.2.

4.2 Concrete class AAA; AA; A, Above Footings; A, Culverts; B, Footings and concrete bridge deck of the type specified will not be measured, but shall be the cubic yard (cubic meter) final pay quantity in accordance with 109.11 for material required within the limits shown on the plans.

4.3 Concrete for bridge deck overlay will be measured by the cubic yard (cubic meter) to the nearest 0.1 cubic yard (cubic meter) based on surface area multiplied by the specified depth.

Basis of Payment

5.1 The accepted quantities of concrete class AAA, AA, A, B, T and F will be paid for at the contract unit price per cubic yard (cubic meter) complete in place, unless otherwise indicated.

5.1.1 The cost of development and testing of alternate mix designs for concrete class F, flowable fill will be subsidiary to the item.

5.2 Concrete class AAA; AA; A, above footings; A, culverts; B, footings and concrete bridge deck of the type specified are final pay quantity items and will be paid for at the contract unit price per cubic yard (cubic meter) in accordance with 109.11.

5.3 Foundation Seal.

5.3.1 Seals shown on the plans will be paid for at the contract unit price per cubic yard (cubic meter) for 520.6.

5.3.2 Seals ordered, but not shown on the plans, will be paid for at the contract unit price per cubic yard (cubic meter) for Class T concrete if Class T is included in the proposal.

5.3.3 Seals requested by the Contractor and permitted, but not deemed necessary, will not be paid for.

5.4 Waterproofing of construction joints shown on the plans or ordered will be paid for under 538.

5.5 Waterstops will be paid for under 541.

5.6 Reinforcing steel will be paid for under 544.

5.7 Weepers and concrete admixtures will be subsidiary.

5.8 The accepted quantity of concrete for bridge deck overlay will be paid for at the contract unit price per cubic yard (cubic meter) complete in place.

5.8.1 Overlay materials rejected shall be removed and replaced by the Contractor at no additional cost to the Department.

5.8.2 Saw cutting concrete for bridge deck overlays as required by 3.5.8.2.3 shall be subsidiary.

5.9 Performance Requirements – QC/QA Pay Adjustments.

5.9.1 Pay adjustments will be paid based on Unit Price (UP), pay adjustment factors as specified below, and the total quantity computed from all accepted delivery records. The UP will be the contract unit price per cubic yard (cubic meter) for the class of concrete involved. Where payment is on a final pay quantity basis, the UP for determining pay adjustments shall be determined by the following method. Multiply the Contract final pay quantity (adjusted Contract final pay quantity, if field changes have been made) by the unit price bid for the item, then divide the result by the total quantity computed from all accepted delivery records for the class of concrete being evaluated.

5.9.1.1 For QC/QA Concrete Class A and Class B, no negative pay factors will be assessed when all test results meet the requirements for each class contained in section 520 of the Standard Specifications however, all provisions of 3.1.6.3.7.1 shall apply.

5.9.1.2 The maximum and minimum percentage pay factors payable under this specification are as follows:

Class AA	+7%	to	–25%
Class A	+ 2%	to	–10%

5.9.2 Concrete with non-conforming strength represented by an acceptance test per sublot will be subject to the following pay adjustment:

$$\text{Pay Factor (for strength in psi)} = 1 + 0.0005(f'ca - f'c)$$

$$\text{Pay Factor (for strength in Mpa)} = 1 + 0.0725\,(f'ca - f'c)$$

Where $f'ca$ = actual compressive strength at 28 days
$f'c$ = specified compressive strength at 28 days

$$\text{Sublot Pay Adjustment} = (\text{Pay Factor} - 1) \times \text{Sublot Size} \times \text{U.P.}$$

Concrete strength greater than the specified compressive strength is not eligible for bonus pay.

5.9.3 Concrete with non-conforming rapid chloride permeability represented by a test value for the sublot greater than 4000 Coulombs up to and including 7000 Coulombs will be subject to the following pay adjustment:

The pay factor for rapid chloride permeability will be made in accordance with the following schedule rounded to 2 decimal places:

Class AA

PERMEABILITY INDEX CHARGE PASSED (COULOMBS)	PAY FACTOR
> 0 and = 1000	**1.05 - 0.00005 (1000 - C)**
>1000 and = 3000	**1.05**
>3000 and = 4000	**1 + 0.00005 (4000 - C)**
>4000 and = 7000	**1+0.0000833(4000-C)**

Sublot Pay Adjustment = (Pay Factor – 1) x Sublot Size x U.P.

C = rapid chloride permeability in Coulombs

5.9.3.1 When the rapid Chloride permeability for any sublot is greater than the upper specification limit as shown in Table 1, the concrete for that sublot will be rejected and subject to the provisions of 106.03.2.2.

5.9.4 A pay factor each for air content and water cement ratio will be calculated in accordance with 106.03.2.4.

5.9.5 Concrete Cover

5.9.5.1 For calculating the pay factor for concrete cover, measurements will be obtained from the GSSI SIR2 radar rebar depth measuring unit and recorded to the nearest 1/8 inch (millimeter). Each measurement will be converted into a number (x) that represents a percentage of the tolerance as listed in Table 1 with a negative number being below target value and a positive number being above target value. The following formula will be used for calculating each x value:

$$x = \frac{(R - TV)}{T}$$

where R = Result obtained from radar unit readings.
TV = Target value from Plans.
T = Tolerance from Table 1.

The x values over the entire lot will be evaluated together for a pay factor in accordance with 106.03.2.4 with USL = 1.00 and LSL = (-1.00).

5.9.5.2 Bridge Decks. In cases where the concrete cover is excessive such that the pay factor is calculated to be between 0.75 and 0.99 inclusive and the Lower Quality Index is 100%, the Contractor may submit calculations that show a live load rating greater than or equal to the design load for the deck. These calculations shall be based on the materials strengths stated in the plans, a "d" based on the 95th percentile cover measurement and shall follow an approved traditional method of analysis. If the calculations are accepted as correct by the Engineer, the negative pay adjustment for excess cover will be multiplied by 0.25. If the calculations are not accepted, all provisions of the specification regarding pay factors will remain in effect. If the concrete cover is excessive to the point where a failed condition results and all of the above conditions are met, the resultant pay factor shall be 0.93.

5.9.5.3 Pedestrian Sidewalks. In the case where concrete cover is excessive such that the pay factor is calculated to be less than 1.0 and the Lower Quality Index is 100%, the pay factor will be 1.0.

5.9.5.4 At Grade Approach Slabs. In cases where concrete cover is excessive such that the pay factor is calculated to be between 0.75 and 0.99 inclusive and the Lower Quality Index is 100%, the

negative pay adjustment for excess cover will be multiplied by 0.25. If concrete cover is excessive to the point where a failed condition results and all of the above conditions are met, the resultant pay factor will be 0.93.

5.9.5.5 Negative pay adjustments for concrete cover will be multiplied by 0.25 for decks constructed in phases and by 0.50 for rail support slabs. All provisions of 3.1.6.3.4.2 shall apply. Pay adjustment provisions for decks constructed in phases shall not be used in conjunction with pay adjustment provisions in 5.9.5.2. If concrete cover on decks constructed in phases is excessive to the point where a failed condition results, the resultant pay factor will be 0.93.

5.9.6 Once the pay factor for permeability, air content, water cement ratio and concrete cover is determined, the following Table 11 and equations will be used to calculate an individual pay adjustment for each measured characteristic.

Table 11 - Weight Factor

MEASURED CHARACTERISTIC	WEIGHT FACTOR "f"		
	CLASS AA	CLASS A	CLASS B
Permeability	0.40	0.00	0.00
Air Content	0.40	0.40	0.20
Water/Cement Ratio	0.20	0.20[1]	0.40[1]
Concrete Cover	0.40	0.40[1]	0.40[1]

[1] This will be assigned a pay factor (PF) of 1.00

The pay adjustment for each measured characteristic per lot (per sublot for permeability) will be determined by the following equations:

For Pay Factors = 1.0:

$$PA_i = (Pf_i - 1)\, f_i (Q)(U.P.)$$

For Pay Factors < 1.0:

$$PA_i = (Pf_i - 1)\frac{f_i}{\sum f}(Q)(U.P.)$$

where:
- PA_i = Pay adjustment payment in dollars for each characteristic.
- Pf_i = Pay factor or composite pay factor for each characteristic.
- f_i = Weight factor from Table 6 for each characteristic.
- $\sum f$ = Sum of weight factors.
- Q = Quantity computed from all accepted delivery records for the lot (sublot for permeability).
- U.P. = Unit price as defined in 5.9.1.

Pay items and units:

520.__	Concrete Class __, _____ (F)*	Cubic Yard (Cubic Meter)
520.001	Concrete Class AAA	Cubic Yard (Cubic Meter)
520.__02	Concrete Class ___,_____(QC/QA)(F)	Cubic Yard (Cubic Meter)
520.03	Concrete Class AA	Cubic Yard (Cubic Meter)
520.0202X	Concrete Class AA, Rail Support Slab (QC/QA) (F)	Cubic Yard (Cubic Meter)
520.12	Concrete Class A, Above Footings (F)	Cubic Yard (Cubic Meter)
520.211	Concrete Class B, Footings (On Rock)	Cubic Yard (Cubic Meter)
520.213	Concrete Class B, Footings (On Soil) (F)	Cubic Yard (Cubic Meter)
520.421	Concrete Class F, Flowable Fill, Excavatable	Cubic Yard (Cubic Meter)
520.6	Concrete Class T, Foundation Seal	Cubic Yard (Cubic Meter)
520.7	Concrete Bridge Deck (F)	Cubic Yard (Cubic Meter)
520.7X02	Concrete Bridge Deck (QC/QA)(F)	Cubic Yard (Cubic Meter)
1010.4X	Quality Control/Quality Assurance (QC/QA) for Concrete	$

* Some of these items may not be a final pay quantity item.

APPENDIX A

NHDOT MICROWAVE PROCEDURE FOR WATER/CEMENT RATIO

1. Tare microwave safe container
2. Place sample of 2000 ±300 grams of concrete in container.
3. Weigh sample in container to nearest gram.
4. Place sample in container into microwave oven at 50% power for one half hour.
5. Weigh container and sample to nearest gram.
6. Place into microwave oven at 50% power for ten minutes.
7. Weigh to nearest gram.
8. Repeat steps 6 & 7 until constant weight is achieved.
9. Calculate Water/Cement (W/C) ratio with the following formula:

$$\mathbf{W/C = (N+1)\ MD - N\ \{ACA\ (1-FA) + AFA\ (FA)\}}$$

Where: $MD = \dfrac{\text{WET WT. - DRY WT.}}{\text{DRY WT.}}$ (Concrete Sample)

$N^* = \dfrac{\text{TOTAL AGGREGATE}}{\text{CEMENT}}$

FA* = RATIO OF SAND TO TOTAL AGGREGATE (DECIMAL)

ACA = ABSORPTION OF COARSE AGGREGATE (DECIMAL)

AFA = ABSORPTION OF FINE AGGREGATE (DECIMAL)

***** Use Actual Batch Weights, not Mix Design

APPENDIX B

CONCRETE EVAPORATION RATE CHARTS

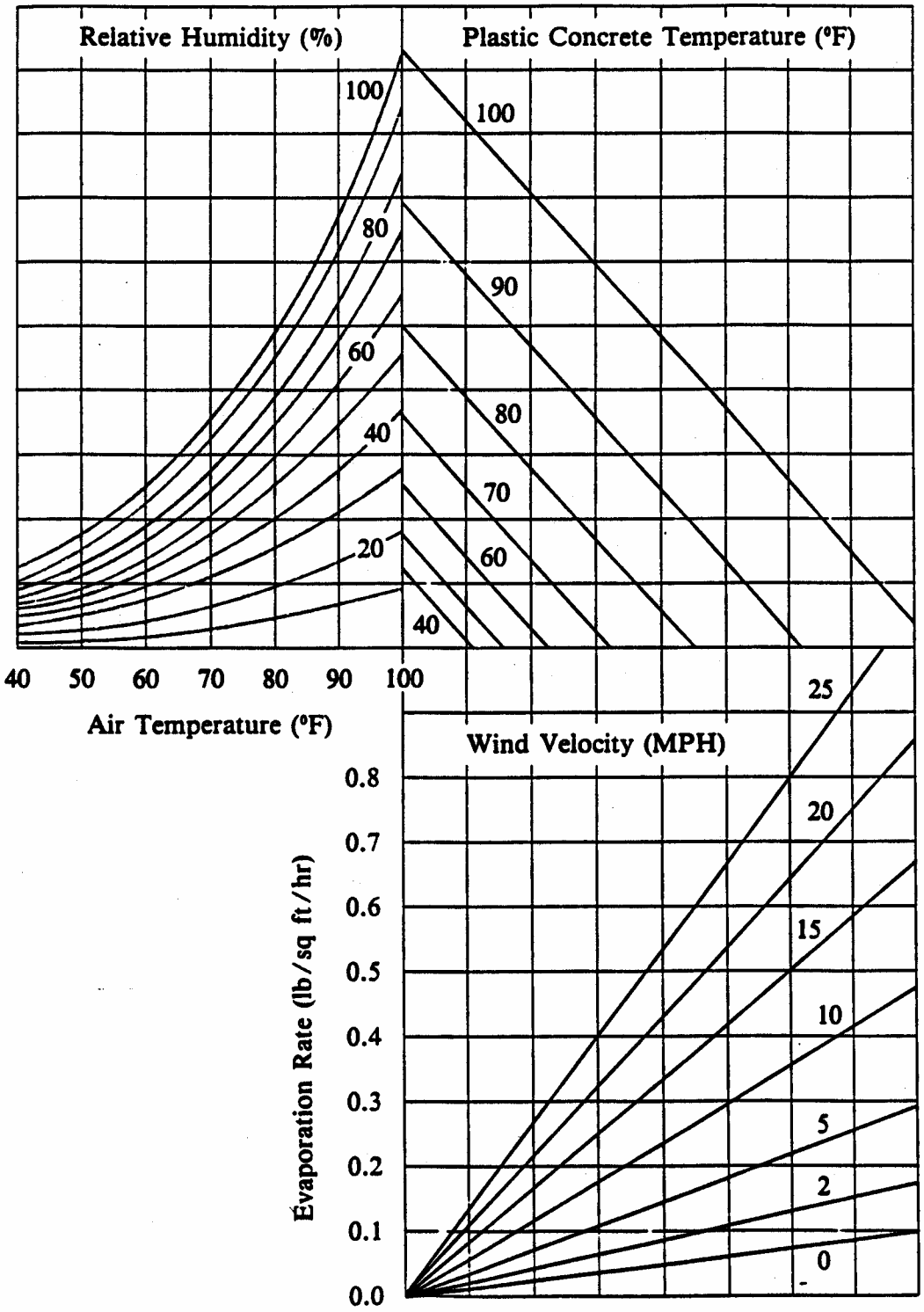


Chart 1 - Evaporation Rate (English)

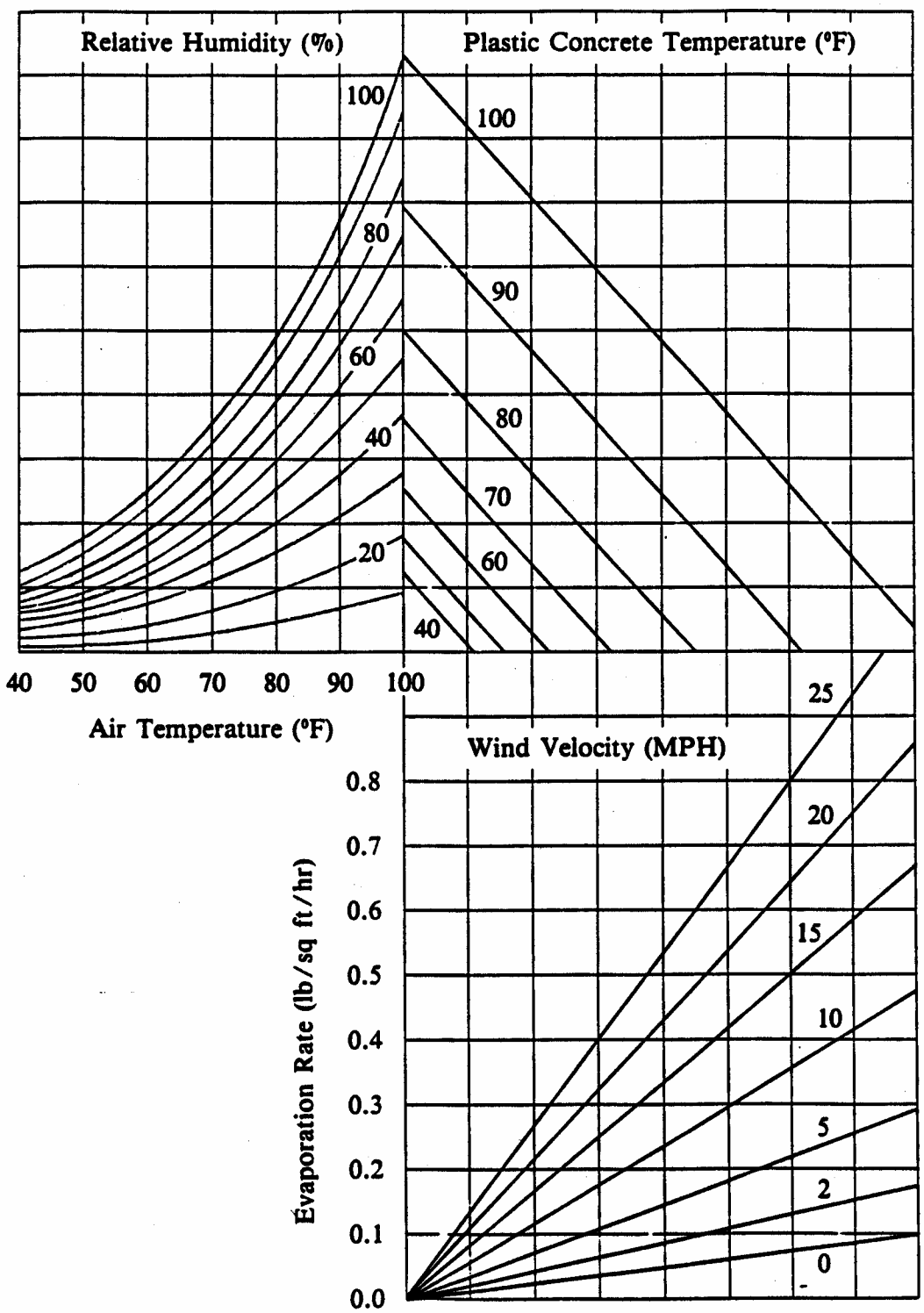


Chart 2 - Evaporation Rate (Metric)

APPENDIX C
EXAMPLE CALCULATIONS FOR PAY ADJUSTMENT (English version)

STEP 1 - STATEMENT OF CONDITIONS AND FIELD TEST RESULTS:

A) Bid price of the Concrete Class AA (QC/QA) item is $373.89/CY, which is also the Unit Price of Concrete (see 520.5.2). The accepted quantity from the delivery records is 337 CY.

B) All samples are to be taken on a statistically random basis with lot sizes based approximately on those values listed in the Acceptance Guidelines adjusted as required to meet field situations.

LOT	DATE	LOCATION	DAY'S PLACEMENT (CY)
1	June 15, 1998	Phase 1 Deck	162
2	June 25, 1998	Phase 1 Sidewalk	14
3	Aug. 25, 1998	Phase 2 Deck	148
4	Sept. 4, 1998	Phase 2 Sidewalk	13
			337

Total =

C) **Strength.** Cylinder design strength is 4000 psi. Strengths will be the average of two cylinders per sublot broken at 28 days. The strength pay factor is not eligible for an incentive pay adjustment.

LOT	DAY'S PLACEMENT (CY)	SUBLOT NUMBER	SUBLOT SIZE (CY) (See 520.3.1.6.3.2)	CYLINDER STRENGTH (PSI)
1	162	1-1	54	7173
1		1-2	54	3770
1		1-3	54	7720
2	14	2-1	14	6970
3	148	3-1	49.33	5150
3		3-2	49.33	6260
3		3-3	49.34	3958
4	13	4-1	13	6580

D) **Permeability.**

LOT	DAY'S PLACEMENT (CY)	SUBLOT NUMBER	SUBLOT SIZE (CY)	PERMEABILITY INDEX (Coulombs)
1	162	1-1	54	1503
1		1-2	54	1056
1		1-3	54	801
2	14	2-1	14	1321
3	148	3-1	49.33	987
3		3-2	49.33	1012
3		3-3	49.34	4806
4	13	4-1	13	5247

E) **Concrete air content.**

LOT	DAY'S PLACEMENT (CY)	SUBLOT NUMBER	SUBLOT SIZE (CY)	AIR CONTENT %
1	162	1-1	54	7.5
1		1-2	54	8.6
1		1-3	54	8.2
2	14	2-1	14	6.4
3	148	3-1	49.33	6.3
3		3-2	49.33	7.9
3		3-3	49.34	5.2
4	13	4-1	13	9.0

F) **Water/Cement ratio.**

LOT	DAYS PLACEMENT (CY)	SUBLOT NUMBER	SUBLOT SIZE (CY)	WATER/CEMENT RATIO
1	162	1-1	54	0.373
1		1-2	54	0.382
1		1-3	54	0.401
2	14	2-1	14	0.424
3	148	3-1	49.33	0.429
3		3-2	49.33	0.390
3		3-3	49.34	0.361
4	13	4-1	13	0.377

G) **Concrete cover**. Cover is measured according to the provisions of 520.5.9.5 from the concrete surface to the closest reinforcing member. Only 6 results shown for illustration purposes.

LOT	LOCATION(STA. TO STA.)	COVER (R)	VALUE (x)
3	Phase 2 Bridge Deck	2 1/4"	-0.50
		2 1/8"	-0.75
		2 1/2"	+0.00
		2 1/4"	-0.50
		2 5/8"	+0.25
		2 1/8"	-0.75

STEP 2 - CALCULATION OF PAY ADJUSTMENT

A) **Strength Pay Adjustments:** Pay Factor (for strength in psi) = 0.0005 (f 'ca - f 'c)

LOT	SUBLOT NUMBER	CYLINDER STRENGTH f 'ca (PSI)	PAY FACTOR	SUBLOT SIZE (CY)	UNIT PRICE ($/CY)	SUBLOT PAY ADJUST ($) (PF x CY x UP)	CUMULATIVE ADJUST ($)
1	1-1	7173	0.000	54	373.89	0.00	0.00
1	1-2	3770	-0.115	54	373.89	-2,321.86	-2,321.86
1	1-3	7720	0.000	54	373.89	0.00	-2,321.86
2	2-1	6970	0.000	14	373.89	0.00	-2,321.86
3	3-1	5150	0.000	49.33	373.89	0.00	-2,321.86
3	3-2	6260	0.000	49.33	373.89	0.00	-2,321.86
3	3-3	3958	0.000	49.34	373.89	0.00	-2,321.86
4	4-1	6580	0.000	13	373.89	0.00	-2,321.86

COMMENTS:

As per Section 520.3.1.6.3.7.1, sublots with test results that are within minus 60 psi of, or higher than, the design strength will not be pay adjusted, but will be paid for at 100% of the unit bid price. All concrete sublots with strengths of more than 500 psi below the mix design strength will be rejected by the Engineer.

Note that all values in the Lots, except one, are within the -60 psi limit

B) **Permeability Pay Adjustments:** See 5.9.3 for pay factor equations.

LOT	SUBLOT NUMBER	PERME-ABILITY INDEX (Coulomb)	PAY FACTOR	SUBLOT SIZE (CY)	UNIT PRICE ($/CY)	SUBLOT PAY ADJUST ($) (See 5.9.6)	CUMULA-TIVE ADJUST ($)
1	1-1	1503	1.05	54	373.89	$403.80	$403.80
1	1-2	1056	1.05	54	373.89	$403.80	$807.60
1	1-3	801	1.04	54	373.89	$323.04	$1,130.64
2	2-1	1321	1.05	14	373.89	$104.69	$1,235.33
3	3-1	987	1.05	49.33	373.89	$368.88	$1,604.21
3	3-2	1012	1.05	49.33	373.89	$368.88	$1,973.09
3	3-3	4806	0.93	49.34	373.89	$-368.95	$1604.14
4	4-1	5287	0.89	13	373.89	$-152.76	$1451.38

COMMENTS: As per 520.5.9.3 Pay Factors will be rounded to 2 decimal places.

C) **Air Content Pay Adjustments:** Lot 2 result shall be evaluated with Lot 1 and Lot 4 shall be evaluated with Lot 3 per 520.3.1.6.3.2. See also 520.5.9.4 for pay factor formula.

LOT/ LOT SIZE	UPPER SPEC LIMIT (USL)(%)	LOWER SPEC LIMIT (LSL)(%)	SUBLOT TEST RESULTS				AVG (x)	STANDARD DEVIATION (s)
1 & 2			1-1	1-2	1-3	2-1		
176	9	5	7.5	8.6	8.2	6.4	7.675	0.964
3 & 4			3-1	3-2	3-3	4-1		
161	9	5	6.3	7.9	5.2	9.0	7.100	1.683

LOT	UPPER QUALITY INDEX (QU)	LOWER QUALITY INDEX (QL)	% WITHIN UPPER LIMITS (PU FROM TABLE 106-1, n=4)	% WITHIN LOWER LIMITS (PL FROM TABLE 106-1, n=4)	QUALITY LEVEL (QL)	PAY FACTOR (FROM TABLE 106-2)
1 & 2	1.37	2.77	96	100	96	1.04
3 & 4	1.13	1.25	88	92	80	1.02

Pay Adjustment (Lots 1 & 2) = (PF-1) x f x CY x UP = 0.04 x 0.40 x 176 x $373.89 = $1052.87

Pay Adjustment (Lots 3 & 4) = (PF-1) x f x CY x UP = 0.02 x 0.40 x 161x $373.89 = $481.57

D) **Water/Cement Ratio Pay Factor Determination:** USL is x+0.030 and LSL is x-0.030.

LOT/ LOT SIZE	UPPER SPEC LIMIT (USL)(%)	LOWER SPEC LIMIT (LSL)(%)	SUBLOT TEST RESULTS				AVG (x)	STANDARD DEVIATION (s)
1 & 2			1-1	1-2	1-3	2-1		
176	0.425	0.365	0.373	0.382	0.401	0.424	0.395	0.023
3 & 4			3-1	3-2	3-3	4-1		
161	0.419	0.359	0.429	0.390	0.361	0.377	0.389	0.029

LOT	UPPER QUALITY INDEX (QU)	LOWER QUALITY INDEX (QL)	% WITHIN UPPER LIMITS (PU FROM TABLE 106-1, n=4)	% WITHIN LOWER LIMITS (PL FROM TABLE 106-1, n=4)	QUALITY LEVEL (QL)	PAY FACTOR (FROM TABLE 106-2)
1 & 2	1.30	1.30	94	94	88	1.03
3 & 4	1.03	1.03	85	85	70	0.98

Pay Adjustment (Lots 1 & 2) = (PF-1) x f x CY x UP = 0.03 x 0.20 x 176 x $373.89 = $394.83

Pay Adjustment (Lots 3 & 4) = (PF-1) x f x CY x UP = -0.02 x 0.20 x 161x $373.89 = -$240.79

E) **Concrete Cover Pay Factor Determination:** See 520.5.9.5. Assume for this example 450 readings were taken from the phase 1 deck and sidewalk surfaces with an overall x value of -0.30 and a standard deviation of 0.411 as determined by the radar depth measuring unit.

LOT	LOT SIZE	UPPER SPEC LIMIT (USL)	LOWER SPEC LIMIT (LSL)	AVG (x)	STANDARD DEVIATION (s)
1&2	450	1.00	-1.00	-0.30	0.411

UPPER QUALITY INDEX (QU)	LOWER QUALITY INDEX (QL)	% WITHIN UPPER LIMITS (PU FROM TABLE 106-1, n>200)	% WITHIN LOWER LIMITS (PL FROM TABLE 106-1, n>200)	QUALITY LEVEL (QL)	PAY FACTOR (FROM TABLE 106-2)
3.16	1.70	100	96	96	1.02

Pay Adjustment (Lots 1&2) = UP x (PF-1) x CY x f = $373.89 x 0.02 x 176 x 0.40 = $526.44
Assume that the phase 2 deck and associated sidewalk yield a 0.99 pay factor:

Pay Adjustment (Lots 3&4) = UP x (PF-1) x CY x f = $373.89 x -0.01 x 161 x 0.40 = -$240.79

STEP 3 – TOTAL PAY ADJUSTMENT:

Strength Pay Adjustment	-$2,321.86
Permeability Pay Adjustment	$1451.38
Air Content Pay Adjustment (Lots 1&2)	$1,052.87
Air Content Pay Adjustment (Lots 3&4)	$481.57
Water/Cement Ratio Pay Adjustment (Lots 1&2)	$394.83
Water/Cement Ratio Pay Adjustment (Lots 3&4)	-$240.79
Concrete Cover Pay Adjustment (Lots 1&2)	$526.44
Concrete Cover Pay Adjustment (Lots 3&4)	-$240.79
Total Class AA Pay Adjustment (Item 1010.4X) =	$1,103.65

NOTE: Pay adjustments may be calculated for each estimate based on all test results to date.

ROUNDING NOTE: Target values and results are rounded to the same places as the specification.
Average (x) and standard deviation (s) are not rounded.
Pay factors, Q_U, and Q_L are rounded to 2 places in all cases.