

CITY OF LINCOLN, NEBRASKA, STANDARD SPECIFICATIONS

CHAPTER 3

PORTLAND CEMENT CONCRETE (PCC)

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CHAPTER 3

PORTLAND CEMENT CONCRETE

3.00 GENERAL

Portland Cement Concrete (PCC) shall consist of an intimate mixture of Portland Cement, aggregate, and water. All Portland Cement Concrete (PCC) shall be air entrained and contain a City Engineer approved water reducing admixture at the manufacturers recommended dosage rate. Portland Cement used in all concrete mixtures except L-5500, LB-3500, LB-2750 and PR shall be an Inter-ground/Blended cement as described below and as indicated in Table 3.01 B. Depending on the application, other constituents or admixtures may be used with permission from the City Engineer. Materials not on the latest edition of the Nebraska Department of Transportation (NDOT) “Approved Products List” or “Nebraska Qualified Material Vendors List” shall not be used without permission from the City Engineer. The constituents of Portland Cement Concrete and their mixing, handling, and proportioning shall conform to ASTM Designation C 94 except as modified herein.

Unless stated otherwise in these specifications Concrete not meeting the 28 day required strength based on cylinders or maturity method as determined by the Engineer shall be removed and replaced at no extra cost to the City. Unless stated otherwise the Engineer may evaluate the concrete’s expected use and may allow it to remain in place at 50% pay.

3.01 MATERIALS

A. CEMENT

Portland Cement shall be a recognized standard hydraulic cement composed primarily of hydraulic calcium silicates conforming to the requirements of ASTM Designation C 150 for Type I, II, or III cement and shall contain no more than 0.60% equivalent alkali. Equivalent alkali is defined as the sum of the sodium oxide (Na₂O) and the potassium oxide (K₂O) calculated as sodium oxide (equivalent alkali as $Na_2O = Na_2O + 0.658(K_2O)$). Certified mill tests shall be furnished to the City’s Project Manager. Different brands of cement, or the same brand from different mills, shall not be mixed during storage. Neither shall they be used alternately in any one concrete placement without permission from the City Engineer. Contractors or Subcontractors supplying concrete shall notify the City’s Project Manager when changing to different cement. No additional supplementary cementitious materials (SCMs) may be added at the concrete plant.

The cement shall be protected from damage due to moisture. Cement so damaged will be rejected. Cement shall not be in storage at the concrete plant longer than ninety (90) days without retesting for quality testing by a facility approved by the City Engineer. The temperature of the cement when used shall be less than 180° F.

B. INTER-GROUND/BLENDED PORTLAND CEMENT CONCRETE (PCC)

All Portland Cement Concrete (PCC) mixes, except those listed above shall be modified by the use of an Inter-ground/Blended cement and shall conform to the requirements in ASTM C595 and the following requirements as specified below.

3.01 MATERIALS (Continued)

B. INTER-GROUND/BLENDED PORTLAND CEMENT CONCRETE (PCC) (Continued)

1. Type IPF Cement

Type IPF cement shall be Portland cement which is pre-blended or inter-ground by the cement manufacturer with a replacement of 25% +/- 2% Class F fly ash and shall conform to the requirements of ASTM C 595. No additional SCMs may be added at the concrete plant.

Fly ash shall conform to the requirements of Class F pozzolan of ASTM Designation C 618, except that the maximum loss on ignition for Class F pozzolan shall be 6.0%. Additionally, Class F pozzolans shall have a maximum allowable free carbon content not to exceed 3.0%. Class F fly ash shall not contain more than 1.50% of available alkalis as Na₂O. Fly ash such as is produced in furnace operations utilizing liming materials or soda ash (sodium carbonate) as an additive will not be acceptable. Certified mill tests shall be provided to the City's Project Manager.

Type IPF may be further modified by a NDOT approved tertiary blend of cementitious materials provided they are incorporated into the final inter-ground/blended cement by the cement manufacturer.

2. Type IS Cement

Type IS cement shall be Portland cement which is pre-blended or inter-ground by the cement manufacturer with a replacement of 35% +/- 5% Slag (Ground Granulated Blast Furnace Slag). No additional SCMs may be added at the concrete plant.

Slag cement shall conform to ASTM C989, Grade 100 or Grade 120. Certified mill tests shall be provided to the City's Project Manager.

Type IS may be further modified by a NDOT approved tertiary blend of cementitious materials provided they are incorporated into the final inter-ground/blended cement by the cement manufacturer.

A City Engineer approved water reducing admixture shall be used in all inter-ground/blended modified concrete mixes at the dosage rate recommended by the manufacturer. The water-cement ratio of all inter-ground/blended modified concrete shall not exceed the maximum limit for the various classes of concrete as shown in Table 3.01 B.

C. AGGREGATE

1. General

Only aggregates that have been approved by the Nebraska Department of Transportation and used for similar Work and have satisfactory service records will be allowed for use on City of Lincoln projects unless approved by the City Engineer.

Mineral aggregates shall be crushed rock, broken stone, gravel, sand-gravel, coarse sand, fine sand, or a mixture of these materials composed of clean, hard, durable, and un-coated particles. Crushed rock shall be crushed limestone, dolomite, granite, quartzite, or other ledge rock.

3.01 MATERIALS (Continued)

C. AGGREGATE (Continued)

1. General (Continued)

Dolomite as herein defined is a magnesium limestone containing calcium carbonate and magnesium carbonate in approximately a 4 to 3 ratio.

The calcium carbonate content of limestone shall be at least 80% computed as CaCO₃ from the value determined for CaO.

Aggregates shall be free from injurious quantities of dust, soft or flaky particles, loams, alkali, organic matter, paper, wood, or other deleterious matter as determined by the City's Project Manager.

The use of aggregate obtained from any reclaiming or recycling process shall not be allowed without permission from the City Engineer.

The gradations shown for the aggregate represent limits which shall determine suitability for use from any source of supply. The gradations from any one source shall be uniform and not subject to the extreme percentages of gradation specified below. The aggregate from different sources of supply shall not be mixed or stored in the same pile, nor used alternately in the same class of construction or mixed without permission from the City Engineer. The aggregate may be tested at any time prior to its incorporation into a mix. Aggregate sampling and testing shall conform to the following requirements:

<u>ASTM</u>	<u>DESIGNATIONS</u>
C33	Specification for Concrete Aggregates

<u>AASHTO</u>	<u>DESIGNATIONS</u>
T96	Abrasion
T104	Sodium Sulfate Soundness
T21	Organic Impurities
T71	Mortar-Making Properties
T84	Specific Gravity and Absorption (Fine Aggregate)
T85	Specific Gravity and Absorption (Coarse Aggregate)
T89	Determining the Liquid Limit of Soils
T90	Determining the Plastic Limit and Plasticity Index of Soils
T248	Reducing Field Samples of Aggregate to Testing Size

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NDOT T2	Sampling
NDOT T27	Sieve Analysis
NDOT T504	Clay Lumps, Shale, and Soft Particles
NDOT T103	Freeze and Thaw Soundness
NDOT C25	Calcium Carbonate

Fine sand shall have at least 95% of its particles pass the No. 10 sieve and no more than 25% pass the No. 200 sieve. This definition applies to the sodium sulfate soundness test.

3.01 MATERIALS (Continued)

C. AGGREGATE (Continued)

1. General (Continued)

Once an aggregate's soundness and abrasion quality has been determined, additional quality testing for soundness and abrasion loss will be at the City's Project Manager's discretion.

Aggregate shall be evaluated based upon its past performance in concrete pavement and in laboratory test results. Aggregate with adversely reactive constituents shall not be used.

During the progress of the Work, should the quality of the aggregate appear to change appreciably, the Contractor may be required to furnish satisfactory evidence of its soundness. The City's Project Manager may, from time to time during the progress of the Work, make check tests of the gradation of the aggregates. Any materials failing to meet the requirements of the Standard Specifications shall be rejected and removed from the site of the Work.

Aggregates shall meet the gradation requirements of Table 3.01 A, for the Class of Concrete shown in Table 3.01 B, of these Standard Specifications. For all other applications such as overlay concrete or mortar and grout sands, the gradation requirements in the latest edition of the Nebraska Department of Transportation "Standard Specifications for Highway Construction" shall apply.

2. Fine Aggregate

Fine aggregate shall consist of sand or sand gravel or a combination of sand and sand gravel. The sand and sand gravel shall be washed and composed of clean, hard, durable and un-coated particles. Aggregates produced from wet pits by pumping will be considered to be washed. Aggregates from a dry pit shall have the method for washing approved by the City Engineer. The fine aggregate shall be free from injurious amounts of clay, loam, alkali, organic matter and other deleterious substances.

Fine aggregate shall have a soundness loss of not more than 10% by weight at the end of 5 cycles using sodium sulfate solution.

The aggregate shall contain no more than 0.5% by weight of clay lumps.

The aggregate which produces a color darker than the standard color when subjected to the colorimetric test for organic impurities shall be tested for its mortar-making properties in conformance with AASHTO T 71.

The aggregate, when subjected to the mortar-making properties test, shall produce a mortar having a compressive strength at the age of 7 days equal to or greater than that developed by mortar of the same proportions and consistency made of the same cement and aggregate after the aggregate has been treated in a 3% solution of sodium hydroxide. Materials failing to produce equal or greater strength shall not be accepted, without permission from the City Engineer.

3.01 MATERIALS (Continued)

C. AGGREGATE (Continued)

3. Coarse Aggregate

Coarse aggregate shall consist of limestone composed of clean, hard, durable, and uncoated particles. These materials are natural sedimentary rock composed principally of calcium carbonate.

The calcium carbonate content of the aggregate shall be at least 80% (computed as CaCO₃ from value determined for CaO).

The percent of clay lumps, shale, or soft particles shall not exceed the following amounts:

Clay Lumps	0.5%
Shale	1.0%
Soft Particles	3.5%

Any combination of clay lumps, shale and soft particles shall not exceed 3.5%.

Coarse aggregate for concrete shall be free of coatings that will inhibit bond and injurious quantities of loam, alkali, organic matter, thin or laminated pieces, chert or other deleterious substances.

Coarse aggregate for concrete shall not have a soundness loss greater than 8% by weight at the completion of 16 cycles of alternate freezing and thawing.

The percentage of wear by the Los Angeles Abrasion test shall not exceed 40%.

TABLE 3.01A – GRADATION LIMITS FOR MINERAL AGGREGATES FOR USE IN PORTLAND CEMENT CONCRETE (% Passing)

Sieve	FINE AGGREGATE		COARSE AGGREGATE	
	Target	Tolerance	Target	Tolerance
1 1/2"	--	--	100	None
1"	100	None	100	-8
3/4"			78	±12
1/2"			--	--
3/8"			30	±15
# 4	87	±10	6	±6
# 10	60	±10	--	--
# 20	--	--	2	±2
# 30	28	±12		
# 50				
# 100				
# 200	1.5	±1.5		

3.01 MATERIALS (Continued)

D. WATER

Water for concrete or mortar shall be clean and free from injurious amounts of oil, acid, alkali, salt, organic matter, and other deleterious substances. Test specimens of mortar made from the materials and water to be used in the Work shall develop a tensile or compressive strength at seven days of not less than 95% of that developed by the mixture of material and distilled water.

Wash-out water or water from the reclaiming process of Portland cement concrete shall not be allowed to be used in the mixture without permission from the City Engineer.

E. CHEMICAL ADMIXTURES

Portland cement concrete shall be air-entrained. Air entraining admixtures to be used with Portland Cement Concrete shall conform to ASTM Designation C 260, except that the strength of the concrete containing the admixture shall not be less than 92% of a similar concrete without the admixture at all test ages. The air entraining characteristics of the admixture, when combined in suitable proportions with Portland Cement, aggregate, and water, within the limits of the proportions specified, shall be such that the resulting concrete will have a satisfactory work-ability and a total air content within the limits, as specified herein, for the different classes of concrete.

If the air content of the concrete at the job site is less than the minimum specified, only one addition of air-entraining admixtures to a load is allowed. If the air content is then outside the limits specified, the load of concrete shall be rejected.

Admixtures which are not incorporated into the mix at the plant shall not be added to individual loads of concrete at the job site to enhance work-ability or pump-ability without permission from the City Engineer.

Admixtures shall not be added to individual loads of concrete at the job site to reduce either air content or slump without permission from the City Engineer.

TABLE 3.01B – PORTLAND CEMENT CONCRETE MIXTURES (CUBIC YARD BATCH)

CLASS OF CONCRETE (1)	GENERAL USE	CEMENT (lb/cy)	CEMENT TYPE (2)	WATER CEMENT RATIO (MAX.)	SLUMP (MAX.) (inches) (3)	AGGREGATES (% BY WEIGHT)		AIR CONTENT RANGE (% BY VOLUME)	28 DAY STRENGTH MIN. PSI
						FINE	COARSE		
SG-3000	Where Specified	564	1PF/IS	0.50	4.0	100	0	6.0 - 8.5	3000
L-3500	Pavement, Sidewalk, Structures	564	1PF/IS	0.50	4.0	70 +/- 3	30 +/- 3	6.0 - 8.5	3500
L-3500S	Slip-form Pavement	564	1PF/IS	0.48	2.5	70 +/- 3	30 +/- 3	6.5 - 9.0	3500
LC-3500	Slip-form Curb	564	1PF/IS	0.48	2.5	70 +/- 3	30 +/- 3	6.0 - 8.5	3500
L-4500	Structures	658	1PF/IS	0.42	4.0	70 +/- 3	30 +/- 3	6.0 - 8.5	4000
LB-2750	Pavement Base (New Construction Residential)	423	I/II	0.60	4.0	60 +/- 2	40 +/- 2	5.5 - 7.5	2750
LB-3500	Pavement Base (Reconstruction)	564	I/II	0.50	4.0	70 +/- 3	30 +/- 3	5.5 - 7.5	3500
L-5500	Pavement (High/Early Strength)	752	I/II	0.40	4.0	70 +/- 3	30 +/- 3	6.0 - 8.5	4000
PR (4)	Pavement Repair (High/Early Strength)	799	III	0.45	4.0	70 +/- 3	30 +/- 3	6.0 - 8.5	4000

NOTES:

- (1) All mixtures shall contain a City Engineer approved water reducer at the manufacturer's recommended dosage rate.
 - (2) Type 1PF or Type IS may be used. For Temporary Pavement, Type I/II cement is allowed.
 - (3) The maximum slump may be exceeded by use of City Engineer approved mid to high range water reducers and/or superplasticizers.
 - (4) Calcium Chloride may be added as per NDOT Standard Specifications for Highway Construction.
- This table is for proportion ranges only. Actual mix design weights for specific applications will be provided or approved by the City Engineer.

3.02 HANDLING MATERIALS

The concrete constituents, when delivered to the mixing equipment, shall meet the requirements of the above Standard Specifications.

The moisture content of the aggregate shall be reasonably uniform from batch to batch. During concrete mixing operations, aggregate moisture tests shall be performed, daily or more often as conditions warrant, by the Contractor on aggregates not controlled by electronic moisture probes. Weight adjustments shall be made accordingly to the aggregate proportions as changes in moisture content occur. Moisture test results shall be made available to the City's Project Manager upon request.

Limestone aggregate having a total moisture content less than the absorption percentage of the aggregate as determined by ASTM C127 shall not be approved for use in Portland cement concrete until it is uniformly saturated with water. The saturation shall be performed sufficiently in advance of mixing operations to accommodate moisture absorption by the aggregate.

3.03 WEIGHING & MIXING

A. CENTRAL BATCH PLANT

The constituents of the concrete shall be weighed or measured separately at a central batch plant. The central batch plant shall be in substantial compliance with the requirements in the Quality Control Manual, Section 3, Certification of Ready Mixed Concrete Production Facilities published by the National Ready Mixed Concrete Association. The Contractor shall be responsible for the calibration of the plant on an annual basis or as deemed necessary by the City Engineer.

The concrete batch shall be either plant-mixed by the central batch plant or truck-mixed using transit mixing trucks or a combination of both. Mixing time shall be in conformance with ASTM C 94 and rate requirements shall be based on the size of drum and the mixing drum manufacturers' Specifications. Mixing time shall start when the cement and water are combined. Agitation of the concrete during transport at a lower rate than the drum manufacturer's mixing specification shall not count toward approved mixing time. The concrete shall be transported to the job site in clean, water tight trucks. A load ticket showing the date, time, plant designation, mix designation, batch size, material quantities per batch, and aggregate moisture values used to calculate aggregate quantities shall accompany each load and be made available to the City's Project Manager.

The temperature of the concrete shall be between 50° F and 95° F when delivered to the Work. The temperature of the combined aggregate and water shall not exceed 95° F.

B. SELF-CONTAINED MOBILE MIXER

Use of this method shall be pre-approved by the Engineer and shall be limited to a maximum of 30 cubic yards per day.

Proportioning and mixing equipment shall be of the self-contained, mobile, continuous mixing type capable of volumetric production of concrete meeting the mix proportions stated in this Chapter and subject to the following.

The mixer shall be self-propelled and be capable of carrying sufficient unmixed dry, bulk cement, fine aggregate, coarse aggregate, admixtures, and water to produce on the site at least 5 cubic yards of concrete. The mixer shall have one bin for each size aggregate.

3.03 WEIGHING & MIXING (Continued)

C. SELF-CONTAINED MOBILE MIXER (Continued)

1. Control and Mixing of Materials

Unless otherwise stated in these specifications, operation and calibration of the mixer shall follow sections 7, 8, and 9 of ASTM C685/17.

The Contractor shall perform calibration tests according to the equipment manufacturer's recommendations every 6 months and when there is a change in the mix design proportions or source of materials. A cement meter calibration shall be performed at the beginning of each project. The Engineer shall be notified prior to the calibration so the process can be observed. The Engineer may require a calibration test or yield check whenever a change in the characteristics of the mixture is observed. Calibration reports and sources of materials shall be kept with the mixer for 2 years and be readily available to the Engineer.

At the end of the concrete placement a printed batch ticket shall be submitted to the Engineer and shall contain the following information. Name of concrete supplier, identification number of batching equipment, serial number of batch ticket, date, starting time, finishing time, name of purchaser, specific designation of job (name and location), designation of concrete mix, amount of concrete in cubic yards, meter count, indication of total quantity of cement, aggregates, water, and admixtures batched.

The temperature of the concrete shall be between 50° F and 95° F when delivered to the Work. The temperature of the combined aggregate and water shall not exceed 95° F.

3.04 CONSISTENCY AND PLACEMENT OF CONCRETE

In general, the minimum amount of water shall be used which will produce the required workability. The mortar shall cling to the coarse aggregate and shall show no free water when removed from the mixer. The upper surface of the set concrete shall show a cement film upon the surface, but shall be free from laitance. In no case shall so much water be used so as to cause the collection of surplus water on the surface, or to cause segregation of the materials during transportation or placing of the concrete.

Concrete shall be plastic, cohesive and workable, and uniform from load to load. Workable concrete is defined as a concrete which can be placed without honeycomb and without surface voids. Work-ability shall be obtained without producing a condition such that free water appears on the surface when finished. The consistency of the mixture shall be that required for the specific conditions and methods of placement; however, the maximum water cement ratio, as specified in Table 3.01 B, shall not be exceeded.

Concrete hauled in non-agitating trucks shall be placed within 30 minutes after mixing time starts. Concrete hauled in agitating or transit mix trucks shall be placed within 90 minutes after mixing time starts. A lesser time may be specified by the City Engineer if, in his/her opinion, conditions warrant it. Concrete exceeding these time limits shall not be incorporated in the pavement or structure.

The maximum allowable interval for placing successive concrete loads on grade for paving or into forms and excavations for structures shall be 30 minutes unless directed otherwise by the City Engineer. Concrete free fall distance shall not exceed 5'. This includes free fall in a discharge pipe when using a conveyor system for placement. Pumped concrete is not considered in free fall until the concrete exits the pumper hose.

3.05 CONCRETE ACCEPTANCE

The Contractor shall notify the City a minimum of 48 hours in advance of the intended concrete placement to allow for inspection of the grade, forms and reinforcement and to enable sampling and testing of the concrete materials at the plant and testing of the concrete at the jobsite. The City Engineer shall take such tests of the concrete as he/she deems necessary to determine the strength and the air, water, cement and aggregate proportions. The properties of the concrete will be determined by the tests specified in ASTM Designation C 94. Any concrete placed without the proper notification will be subject to removal and replacement.

3.06 FLOWABLE FILL

A. DESCRIPTION

Flowable Fill for general use shall be a mixture of cement, fly ash, fine sand, water, and air having a consistency which will flow under a very low head.

B. MATERIALS

The approximate quantities of each component per cubic yard of mixed material shall be as shown in Table 3.06 A. Other materials and amounts may be used depending on the intended application of the flowable fill with approval of the City Engineer.

TABLE 3.06A – FLOWABLE FILL COMPOSITION PER CUBIC YARD

Cement (Type I or II)	60 pounds
Class C Fly Ash	200 pounds
Fine Sand (ssd)	2,700 pounds
Water (approx.)	420 pounds
Air Content (approx.)	10%

Actual quantities shall be adjusted to provide a yield of 1 cubic yard with the materials used.

Approximate compressive strength should be 85 to 175 psi.

Fine Sand shall be an evenly graded material having not less than 95% passing the No. 4 sieve and not more than 5% passing the No. 200 sieve.

Handling and mixing of the materials shall be in conformance with these Standard Specifications.

Cement must be on the latest NDOT Approved Products List or “Nebraska Qualified Material Vendors List”.

3.06 FLOWABLE FILL (Continued)

C. BASIS OF PAYMENT

FLOWABLE FILL that has been completed in conformance with the Plans and Standard Specifications and accepted by the City's Project Manager shall be paid for at the contract unit price bid per cubic yard based on the ticketed volume of material delivered to the site. No payment shall be made for materials furnished in excess of that specified in the Contract or approved by the City's Project Manager. Such payment shall be full compensation for all materials, hauling, installing, equipment, tools, labor and incidentals necessary to complete the Work.

3.07 HOT/COLD WEATHER CONSTRUCTION

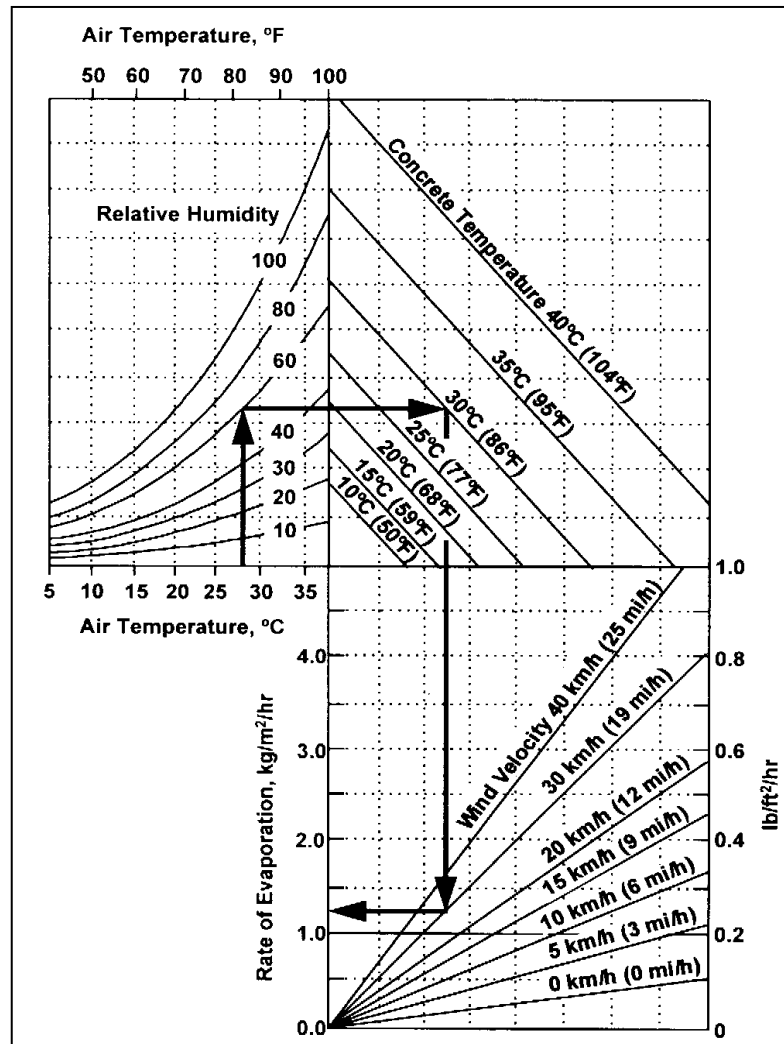
A. CONCRETE CONSTRUCTION – HOT WEATHER

To reduce plastic shrinkage and cracking, the following conditions shall be considered:

1. Concrete temperatures
2. Air temperatures
3. Humidity
4. Wind velocities

When these conditions combine to create a rate of evaporation equal to or greater than 0.2 pounds per square foot per hour (as determined by Figure 3.07), the Contractor shall take action, satisfactory to the City’s Project Manager, to prevent plastic shrinkage cracking.

FIGURE 3.07 - HOT WEATHER CONCRETING EVAPORATION NOMOGRAPH



3.07 HOT/COLD WEATHER CONSTRUCTION (Continued)

B. CONCRETE CONSTRUCTION – COLD WEATHER

Concrete shall not be placed in inclement weather except with permission from the City Engineer. The air temperature for placing concrete shall be 35° F and rising. No concrete shall be placed on a frozen sub-grade. When air temperatures can be anticipated below 35° F, the concrete shall be preheated such that the temperature of the fresh concrete in place is a minimum of 55° F. Concrete aggregates shall be protected to prevent freezing and to maintain total moisture content above the absorption percentage of the aggregate as determined by ASTM C127.

The pavement or structure shall be maintained for 72 hours at a minimum of 50° F with heat and/or adequate layers of burlap, plastic, insulated blankets, or other approved materials. No open flame heat source without proper venting to protect the fresh concrete from the exhaust gases.

The concrete shall have achieved the minimum specified strength prior to any subsequent construction or loading of the pavement or structure. If deemed necessary, the Engineer may require a 28 day strength core to verify that the concrete has not been damaged by the cold weather. The core shall be taken at no additional cost to the City within 35 days of placement, under the direct supervision of the Engineer and taken to the City Lab for testing. Any failure to meet specified strength will be subject to the strength pay factors in Section 4.14.