SECTION 1002 -- PORTLAND CEMENT CONCRETE

1002.01 -- Description

1. Concrete shall consist of aggregate, portland cement, water, approved air-entraining and other admixtures, and pozzolans as required or allowed by these *Specifications*.

2. All pay items that include the class of concrete will have the appropriate designation added to the pay item to show the 28-day compressive strength. For example, 47B concrete with a 28-day compressive strength requirement of 25 MPa shall be identified as Class 47B-25. The 7-day compressive strength should be 70 percent of the 28-day compressive strength.

1002.02 -- Material Characteristics

1. All materials shall conform to the requirements in Table 1002.01.

Table 1002.01

Material Requirements	
Applicable Materials	**Section**
Portland Cement	1004
Water for Concrete	1005
Concrete Aggregate	1033
Fly Ash	1008
Admixtures	1007
Silica Fume	1009

2. The Contractor may elect to substitute an acceptable class of concrete shown in Table 1002.02 at no additional cost to the Department. The Engineer shall be notified of any substitutions before batching the concrete.

3. Type III portland cement shall be used in Class PR3 and 47B-PHE concrete. Type I and II portland cement shall be used in all other classes of concrete.

4. a. The temperature of the mixed concrete shall be not less than 10°C immediately after being placed.

b. When the air temperature in the shade and away from artificial heat is less than 2°C, the Engineer may require the water and/or aggregates to be heated to not less than 21°C nor more than 65°C, such that the temperature of the mixed concrete shall not be less than 10°C at the time of placement.

c. Stockpiled aggregates may be heated by the use of dry heat or stream. Aggregates shall not be heated directly by gas or oil flame or on sheet metal over fire. Aggregates may be heated in bins with a steam-coil or water-coil system or by other methods which are not detrimental to the aggregates.

d. Heating equipment or methods which alter or prevent the entrainment of the required amount of air in the concrete shall not be used. The apparatus used shall heat the aggregate uniformly and shall be so arranged as to preclude the possible occurrence of overheated areas which might damage the aggregates.

Table 1002.02

Concrete Proportions				
	Cementitious Material (kilograms per cubic meter)			
Class of Concrete (1), (6), (7)	Total Min.	Portland Cement Min.	Fly Ash Max.	Silica Fume Min.
47B-25	335	285	58	
47B-SG-20	335	285	58	
47BD-30	30	332	67	
47B-Special-25	363	308	63	
AX-25	390	332	67	
PR1-25	446	446	Exclude	
PR3-25	474	474	Exclude	
Overlay Concrete SF-25	365	335	Exclude	30
Overlay Concrete HD-25	488	488	Exclude	
47B-HE-25	335	335	Exclude	
47B-P-5	390 to 418	332 to 355	67 to 72	

(1) Each class shall identify the minimum strength requirement. (For example, 47B-25, where the last two digits indicate the strength in Megapascals. In the chart, a strength of 25 Mpa is indicated for 47B-25; however, other strengths may be authorized elsewhere in the contract. The classes shown in the chart are typical examples.)

(2) As determined by NDR T 121 or NDR T 152.

(3) Coarse aggregate shall be limestone unless otherwise specified.

(4) The Contractor is responsible to adjust the water/cement ratio so that the concrete supplied achieves the required compressive strength without exceeding the maximum water/cement ratio. The maximum water/cement ratio for any pavement concrete is 0.45. All ratios greater than 0.45 apply only to structures like bridge abutments, piers, or foundations.

Table 1002.02

Concrete Proportions

Percent Air Content (2)		Slump (millimeter) (7)		Percent Coarse Agg. to Total Agg.	Water/ Cementitious Ratio Max.
Min.	Max.	Min.	Max.	(3)	(4)
5.0	7.5		75	30±3	0.48
5.0	7.5		75	(5)	0.48
5.0	7.5	20_8	100	30±3	0.42
5.0	7.5		75	30±3	0.48
5.0	7.5		75	(5)	0.48
4.0	7.0		175	30±3	0.40
4.0	7.0		75	30±3	0.45
4.0	7.0		175	50±3	0.38
5.5	7.5	15	25	50±5	0.45
5.0	7.5		175	30±3	0.40
3.0	6.0		175	30 to 60	0.45

(5) Single aggregate (sand-gravel) used for these classes of concrete.

(6) All classes of concrete shall be air-entrained.

(7) The maximum slump may be exceeded by use of water reducer, high range water reducer, or both.

(8) When bridge curb is placed with slip form equipment, there is no minimum slump requirement.

Table 1002.03

Table of Acceptable Concrete Class Substitutions	
Class Specified	**Acceptable Class for Substitution**
47B-SG	AX, 47B, 47BD, 47B-HE, or 47-HE
AX	47B, 47BD, 47B-HE, or 47HE
47B	47BD, 47B-HE, or 47HE

e. Steam may be used to heat aggregates. When live steam is used in stockpiles, it shall be used in such a manner as to preclude excessive moisture variations within the material. Material containing frost or frozen material shall not be used in the mix.

5. Class PR3 Concrete:

a. The calcium chloride for use in Class PR3 concrete shall be either:

(1) A commercially prepared solution with a concentration of approximately 32 percent by mass.

(2) A contractor prepared solution made by dissolving 0.54 kg of Grade 2 or 0.74 kg of Grade 1 calcium chloride per liter of water to provide a solution of approximately 32 percent by mass.

b. The 0.89 kg of water in each liter of solution shall be considered part of the total water per batch of concrete.

c. The calcium chloride solution shall be added, just prior to placement, at a rate of 3.13 L/100 kg of cement (1.4 kg calcium chloride per 100 kg cement).

d. Class A, Flaked Calcium Chloride shall be added at a rate of 2.0 percent of the mass of the cement for Grade 1 or 1.6 percent of the mass of the cement for Grade 2.

e. An approved Type B set retarding admixture shall be used.

f. Where mixing trucks are used, calcium chloride shall be thoroughly mixed into the concrete before placement. The minimum mixing time is 60 seconds.

g. Where continuous batching equipment is employed, such as the concrete mobile, the calcium chloride solution shall be incorporated in the concrete through a flow meter.

6. a. For Class PR1 concrete, calcium chloride shall be added first and then the concrete mixed at least 2 minutes. Next, the Type F admixture is added and the concrete is mixed at least 5 minutes.

b. The maximum allowable slump after the addition of the admixtures is 175 mm.

c. Flaked calcium chloride and Type F high range water-reducer admixture shall be added to the mixing truck according to the procedures in Subsection 1007.03.

d. The Contractor may not use liquid calcium chloride in Class PR1 concrete.

7. a. High Early (HE) strength concrete shall be cured as prescribed in Subsection 603.03, Paragraph 6.a.(1) when the ambient air temperature is 21°C or higher.

b. (1) If the ambient air temperature is less than 21°C, then 47B-HE-25, 47-HE-25, and all other High Early (HE) concrete shall be covered with polyethylene film and insulation board immediately after the curing-compound has been applied.

(2) The insulation board shall have an R-value equal to or greater than (1.0 m^2) C/W.

(3) The insulation board shall be protected from the rain.

(4) Insulation must be covered with sheeting to form a tight seal around the concrete and must be adequately anchored to keep the insulation in place.

(5) Insulation board and sheeting shall be maintained for at least 48 hours.

c. High early concrete shall achieve a compressive strength of 25 MPa at 48 hours after initial set.

d. The 48-hour compressive strengths shall be used to determine pay factor deductions for high early concrete in accordance with Table 603.02.

8. a. Fly Ash (see Section 1008) may be used in all classes of concrete except those listed as "Exclude" in Table 1002.02.

b. A water-reducing admixture at the manufacturer's recommended dosage is required when using fly ash.

c. Prescribed quantities of fly ash may be used year-round provided loads are not placed on the concrete until the concrete achieves the required compressive strength.

9. Aggregate mass in Table 1002.04 is based on an aggregate bulk specific gravity of 2.62 in a saturated surface-dry condition. When the saturated surface-dry specific gravity of the fine and course aggregates differ by more than 0.01, the mass of the fine and coarse aggregates shall be adjusted by multiplying by the factors in Table 1002.04.

10. The yield of the concrete proportions shall be determined and adjusted by the Engineer.

1002.03 -- Procedures

1. The Contractor shall identify the plant that will supply the concrete 14 days before use and be entirely responsible for its calibration.

2. Portland cement concrete shall be supplied by only those plants determined by the Engineer to 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.

Table 1002.04

Specific Gravity Correlation Factors			
Specific Gravity	**Correction Factor**	**Specific Gravity**	**Correction Factor**
2.75	1.050	2.62	1.000
2.70	1.030	2.61	0.997
2.69	1.026	2.60	0.993
2.68	1.022	2.59	0.989
2.67	1.019	2.58	0.985
2.66	1.015	2.57	0.981
2.65	1.012	2.56	0.977
2.64	1.008	2.55	0.974
2.63	1.004	2.50	0.955

3. The Contractor shall have a furnished testing laboratory on the project site. In the event that concrete is obtained from a commercial supplier, the supplier shall have a furnished testing laboratory at the site where the concrete is produced.

4. Mix times shall meet the requirements of ASTM C 94. Mixing time tests shall be repeated whenever the concrete appearance indicates that mixing was inadequate.

5. The Contractor shall furnish the Engineer a weekly concrete placement schedule that is updated as necessary. The Engineer may observe any or all of the procedures and shall have access to all reported data during production and placement. Any inconsistencies shall be reported to the job superintendent and noted in the Engineer's diary.

6. Delivery tickets shall be prepared as prescribed in the National Ready Mixed Concrete Association's *Quality Control Manual*. A ticket shall accompany each load to the delivery site and be available for the Engineer.

7. Aggregates from different sources shall be stockpiled separately. Aggregates produced by pumping from different pits in the Platte River Valley shall be considered to be from the same source. Aggregate production and quality of concrete are subject to the approval of the Department.

8. Coarse aggregate shall be uniformly saturated with water before it is used. The wetting shall begin 24 hours before concrete mixing to allow complete saturation.

9. a. Cementitious materials shall be stored separately according to material type, class, and source. Similar materials from different sources shall not be mixed or stored together or used alternately in the same concrete placement without permission of the Engineer.

b. When the same scale is used to determine the mass of more than one cementitious material, the mass of the portland cement shall be determined first.

c. Cementitious materials shall be stored in watertight bins.

10. Concrete mixers shall have a 6 mm diameter drilled hole at the midpoint of each blade located at the point(s) recommended by the manufacturer.

11. Concrete transported in truck mixers or agitators shall be discharged within 90 minutes after the introduction of the cement to the aggregate. In hot weather, or under other conditions contributing to stiffening of the concrete, a shorter time may be specified by the Engineer.

12. Concrete transported in non-agitating trucks (i.e., dump trucks) shall be discharged within 30 minutes after the introduction of the cement to the aggregate. In hot weather, or under other conditions contributing to stiffening of the concrete, a shorter time may be specified by the Engineer.

13. a. The quantity of water shall be determined by the Contractor. The minimum quantity of water should be used which will produce the required workability.

b. If the water/cement ratio is varied by more than 1 percent, an air test shall be performed and cylinders made to determine if the concrete is acceptable.

c. Water added to any mix must pass through an approved and adjustable water-measuring device.

14. a. If additional mixing water is added, a minimum of 20 revolutions of the truck mixer drum at mixing speed shall be required.

b. In no case shall the total amount of water in the batch exceed that allowed in Table 1002.02.

c. No water may be added after discharge has begun.

15. a. (1) Mobile mixers shall be self-contained and continuously mix the concrete.

(2) The mixer shall be self-propelled and shall be capable of carrying unmixed, dry bulk cement, aggregate, and water.

(3) The mixer shall measure the volume of cement added to the mix. A recording meter visible at all times and equipped with a ticket printout shall indicate this quantity.

b. Water flow into the mixing chamber shall be automatically controlled. Water flow shall be indicated by flow meter and shall be readily adjustable to provide for minor variations in aggregate moisture.

c. The Contractor shall calibrate the aggregate gates once each year. However, the cement meter must be calibrated at each project site. The Engineer shall be given advance notice of the calibration tests so they can be observed.

16. Hand mixing will be allowed only on small jobs or in the case of an emergency. When hand mixing is allowed, it shall be done on a watertight platform.

1002.04 -- Acceptance Requirements

1. a. Any combination of aggregates which requires the use of more than the specified maximum kilograms of water per 100 kg of cement to produce a workable mixture with the brand and type of cement to be used will be considered as being unsatisfactory, and all such combinations will be rejected.

b. However, the Contractor may elect to use a water reducing admixture to improve the workability of any unsatisfactory mix if the amount of mixing water is within the requirements of Table 1002.02.

2. The quantity of water to be used shall be determined by the Contractor. It shall not be varied without the Engineer's consent.

3. If the concrete mixture is excessively wet causing segregation, excessive bleeding, or any other undesirable condition, the concrete shall be rejected. At the option of the Engineer, slump tests may be performed to determine the consistency.

4. Concrete which has developed initial set before it is consolidated and finished shall be rejected.

5. a. If false set is encountered, the batching operation shall be stopped until the problem is resolved.

b. Permission may be granted for the use of cement and aggregates already combined in the truck mixers, central plant mixers, transit mix trucks, or truck agitators.

c. Each batch must be mixed or agitated for at least 3 additional minutes after observing the false set, and the concrete must be of satisfactory consistency.

6. Compressive strength tests shall be made in accordance with AASHTO T 22. Compressive strength cylinders shall be cured in accordance with AASHTO T 23, Paragraph 9.4. The compressive strength requirements shall be as specified. In general, 7-day compressive strength should be 70 percent of the 28-day compressive strength.

7. Concrete shall be sampled as prescribed in the NDR *Materials Sampling Guide*. Samples shall be taken at the point of placement, never before the discharge from the last conveyance.