

817 PORTLAND CEMENT CONCRETE MIXTURES**817.01 PCC MIX DESIGN**

(A) **GENERAL.** Concrete shall be proportioned within allowable tolerances of an approved mix design. An approved mix design shall consist of an approved concrete producer, materials sources, class of concrete, and material types and proportions. Mix designs for each project must be approved by the Chief Engineer. Approval of a mix design for a specific project, purpose or use does not approve its use for any other project, purpose or use.

Mix design information submitted shall have been obtained from measurements on a trial mix prepared with ingredients from the same source(s) as proposed for use. Mix designs shall have been prepared within 12 months prior to the date submitted. In the event such a mix design is not in full compliance with applicable specifications, further production of that PCC mix shall be suspended until an approved mix design has been obtained in accordance with these specification requirements. Any deviation from the approved mix design will require the approval of the Chief Engineer.

Methods of proportioning mix designs shall be in conformance with ACI 211.1 for normal and heavy weight concrete, ACI 211.2 for lightweight concrete, and ACI 211.3 for no slump concrete.

Each PCC mix design submitted for approval shall include the following:

1. Name and Location of Project and Contract Number
2. Name and Address of Contractor
3. Name and Address of Concrete Producer
4. Mix Design Designation(s)
5. Class(es) of Concrete
6. Uses of Concrete
7. Source Name and Location of Fine Aggregate, Coarse Aggregate, Cement, Admixtures and Water.
8. Type of Cement
9. Cement Content in pounds per cubic yard of concrete
10. Saturated Surface Dry Weight of Coarse and Fine Aggregates in pound per cubic yard of concrete.
11. Water Content, including free moisture in the aggregate, plus water in the drum, exclusive of absorbed moisture.
12. Dosage of Admixture(s).
13. Sieve Analysis of Fine and Coarse Aggregate.
14. Absorption of Fine and Coarse Aggregate.
15. Bulk Specific Gravity (dry and SSD) of Fine and Coarse Aggregate.

16. Dry Rodded Unit Weight of Coarse Aggregate in pounds per cubic foot.
17. Fineness Modulus (FM) of Fine Aggregate.
18. Materials Certification for Cement, Admixtures and Aggregates.
19. Slump of Plastic Concrete in inches.
20. Air Content of Plastic Concrete in percent by volume.
21. Unit Weight of Plastic Concrete in pounds per cubic foot.
22. Seven Day Compressive Strength of Concrete in pounds per square inch.
23. Twenty-eight Day Compressive Strength of Concrete in pounds per square inch.

Up to 50 calendar days may be required for review of a proposed PCC mix design in Category 1 or 3 after it has been submitted for approval. In order to minimize the time between Notice to Proceed and completion of mix design reviews for Category 3 submittals, the apparently successful bidding Contractor may submit proposed mix designs for project approval at anytime after bid opening date. Review of alternate mix designs may require longer than 50 calendar days.

- (B) PROPORTIONS.** Concrete mixtures shall be proportioned so as to secure a workable, homogeneous, placeable mixture which meets the requirements of [817.03](#) for its intended use. The concrete shall be proportioned by weight and shall consist of portland cement, fine aggregate, coarse aggregate, water, admixture(s) and other ingredients as may be specified. Unless specified otherwise, strength values are the average of two companion test cylinders.

817.02 MATERIALS

Portland Cement – [801.01](#)

Granulated Iron Blast Furnace Slag – [801.04](#)

Masonry Cement – [801.02](#)

Fly Ash – [801.05](#)

Fine Aggregate

1. Normal Weight – [803.01](#)

2. Light Weight – [803.07](#)

Coarse Aggregate

1. Normal Weight – [803.02](#)

2. Light Weight – [803.07](#)

Admixtures

1. Air Entraining – [814.04](#)

2. Chemical Admixtures – [814.05](#)

3. Color – [814.06](#)

Water – [822.01](#)

Formulated Latex Modifier – [821.15](#)

817.03 DESIGN CRITERIA

Proportions of concrete shall be such that the design criteria herein are met for the respective class of concrete.

(A) CLASSES OF CONCRETE. Unless otherwise specified, the following classes of concrete shall be used.

CLASS	DESIGNATION	USES
A	Structural Trap Rock	Bridge Decks, sidewalks, approach slabs, and medians for superstructures. Suitable for all uses specified for Class B, Structural.
B	Structural	Reinforced structures, footings, slabs, beams, girders, columns, piers, abutments, walls, arch ribs, box culverts, precast piles, traffic barriers, and cribbing. Sewer and water work except thrust blocks and pipe cradle.
C	High Early Strength	For special and emergency uses as approved by the Chief Engineer.
D	Prestressed	Used for prestressed or post tensioned members.
E	Paving	Alleys, alley and driveway entrances, curbs and gutters, pavements and base.
F	General	For general use and in sidewalks, bike paths or as specified.
H	Lightweight	As specified.
I	Low Slump	As specified.
J	Latex Modified	As specified.

(B) DESIGN REQUIREMENTS. Granulated slag may be used in an amount not to exceed 50 percent by weight of cement. Cement factor and water-cement ratio is determined on basis of combined granulated slag and cement weight.

Fly ash and granulated slag may not be used in the same mixture.

**TABLE 817.03 - PORTLAND CEMENT CONCRETE MIXTURES
The Concrete Mixes Shall Conform to the Following:**

Class Designation	Min. 28 Day Compressive Strength (psi) ^a	Min. Cement Content (Lbs./Yd ³)	Max. Water (Lbs. Water per Lbs. Cement)	Coarse Aggregate Size No. ^b	Slump (In.) ^c	Field Air Content (% by Volume)	Max. Unit Weight (Lbs./Ft. ³)
A ⁴⁸ STRUCTURAL TRAP ROCK	4,500	658	0.44	57 or 67	2-3	5-7.5	
B ⁴⁸ STRUCTURAL	4,500	658	0.44	57 or 67	2-3	5-7.5	
C ⁴⁸ HIGH EARLY	3,000 ^(24 HRS)	800	0.38	57	0-3	4-8	
D ⁴⁸ PRESTRESSED	5,000	680	0.43	57	0-4	4-8	
E ⁴⁸ PAVING	3,500	565	0.49	57, 57 & 4 or 67 & 4	0-3	4-8	
F ⁴⁸ GENERAL	3,500	565	0.49	67, 57, 57 & 4 or 67 & 4	1-5	4-8	
G PIPE CRADLE (ONLY)	2,500	470	0.55	67, 57	1-5	4-8	
H1 ⁴⁸ LIGHTWEIGHT	4,000	658	0.44	3/4 to 4	0-4	5.5-8	122-PLASTIC
H2 ⁴⁸ LIGHTWEIGHT	4,000	658	0.44	3/4 to 4	0-4	5.5-8	117-28 DAD* 115-PLASTIC 110-28 DAD*
I ⁴⁸ LOW SLUMP	4,500	820	0.45	78 ^b	1 MAX.	5.5-7	
J ⁴⁸ LATEX MODIFIED	4,000	660	0.40	7	4-6	3-7	

*DAD = Day Air Dry

- The Materials Engineer may approve mix designs, pending 28 day strength results based on the 7 day compressive strength which results that equals or exceeds 85 percent of the compressive strength and provided that no accelerator or early strength cements are used (except for Class "C"). The compressive strength is defined as the average of 2 cylinders made in the field and cured in the laboratory.
- Crushed trap rock shall be used in class I Low Slump concrete if used in concrete for bridge deck, sidewalk and for median superstructures. Polish susceptible aggregates as defined in 402.02(E) shall not be used for concrete pavement surfaces.
- A maximum slump as limited by the mix design will be allowed for concrete approved with water reducing admixtures. High range water reducer may be used for concrete to be placed at higher slump with the approval of the Engineer provided that there is no aggregate segregation and the entrained air of the concrete at point of placement is within acceptable range.
- Polish susceptible fine aggregates as defined in 402.02(E) shall not be used for concrete pavement surfaces.
- Latex emulsion shall not exceed 3.5 gallons per 94 pounds cement. The latex will weigh approximately 8.40 to 8.55 pounds per gallon.
- Latex emulsion is included as part of the maximum water.
- Fly ash may be substituted for cement such that not more than 15 percent by weight of cement is removed. The mix may require more fly ash added than cement removed. Cement factor and water-cement ratio determined on basis of combined fly ash (replacing the cement) and cement weight. Granulated slag may be used in an amount not to exceed 40 percent by weight of cement. Cement factor and water-cement ratio is determined on basis of combined granulated slag and cement. Fly ash and granulated slag may not be used in the same mixture for cement substitute.
- The chert content of the combined coarse aggregate shall be less than 3.0 percent as per AASHTO M80 Class A.
- Course and Fine aggregate shall conform to 803.07.
- Must be approved by the Engineer prior to use.

- a. The Chief Engineer may approve, pending 28 day strength results, mix designs on the basis that 7 day compressive strength results equal or exceed 85 percent of the minimum average strength requirement as determined in [817.01\(B\)](#) provided no accelerators or early strength cements are used.
- b. Crushed traprock per [803.02](#) shall be used in Class 1 concrete if used in concrete for bridge deck, sidewalk and median of superstructures.
- c. Consistency limits are those allowable with water. A maximum slump as limited by the mix design will be allowed for concrete approved with water reducing admixtures.
- d. Fine aggregate shall conform to [803.01](#).
- e. Light weight fine aggregate shall conform to [803.07](#).
- f. Latex emulsion conforming to [822.15](#) shall be added in an amount of 3.5 gallons per 94 pounds of cement. The latex will weigh approximately 8.40 to 8.55 pounds per gallon.

Proportions of cement to fine aggregate to coarse aggregate on a dry weight basis shall be 1 to 2.5 to 2.0 with a tolerance of 10 percent on the fine and coarse aggregate ratios.
- g. Latex emulsion is included as part of the maximum water.
- h. Fly ash may be substituted for cement such that not more than 15 percent by weight of cement is removed. The mix may require more fly ash added than cement removed. Cement factor and water-cement ratio determined on basis of combined fly ash and cement weight. Fly ash shall conform to the requirements of [801.05](#).

(C) PROTECTION OF CONCRETE AGAINST ALKALI REACTIVITY

Fine and coarse aggregates for use in concrete that will subject to wetting, extended exposure to humid atmospheric conditions or contact with moist ground shall not contain any material that is deleteriously reactive with alkalies in the cement in an amount sufficient to cause excessive expansion of mortar or concrete, except that if such materials are present in injurious amounts, the fine and coarse aggregates may be used with a cement containing less than 0.6 percent alkalies calculated as sodium oxide or with the addition of a material that has been shown to prevent harmful expansion due to the alkali-aggregate reaction.

When the concrete will be subjected to external sources of alkalis and/or chlorides, the aggregates used shall not contain more than 3 % reactive constituents as defined by ASTM C 295, and pass at least one of the following criteria as may be applicable in accordance with ASTM C289, C227, C586, C9 and C1260.

817.04 DESIGN ADJUSTMENTS

Concrete mix design can be revised to improve placement during cold, hot or unusual weather as long as the requirements of [803](#) are met and the revision is approved by the Chief Engineer.

When sources of materials change from those of the approved mix design or when the fineness modulus of the fine aggregate changes by more than 0.20 from the mix design, the mix design will be reviewed and may require a new design.

In the event concrete with the required workability or consistency can not be obtained within the maximum water cement ratio with the materials furnished by the Contractor or producer, changes shall be made as necessary to secure the desired properties subject to the requirements of [817](#) and the approval of the Chief Engineer.

817.05 LOW PERMEABILITY STRUCTURAL CONCRETE

At least two trial batches shall be prepared using approved Portland Cement Concrete (PCC) mix design materials. Test specimens shall be cast by the Contractor and tested by a certified laboratory for permeability and strength at least thirty (30) calendar days prior to construction. The permeability samples shall be cylindrical, four (4) inches in diameter and six (6) inches in length. The samples shall be moist cured as per ASTM C-39, except that the last twenty-one days shall be cured at a temperature of $38^{\circ}\text{C} \pm 6^{\circ}$ ($100^{\circ}\text{F} \pm 10^{\circ}$). Test cylinders shall be tested at twenty-eight (28) calendar days as per ASTM C-1202 and reported as the average of two (2) test specimens from each lot. (100 cubic yards). Permeability values obtained for trial batches shall be 500 coulombs below the maximum values specified in Table 817.05.

Acceptance Tests

A lot shall be a day's production of PCC for the job. For each set of cylinders made for compressive strength tests, two additional cylinders shall be made for the permeability testing purposes.

For all classes of PCC, initially one set of permeability cylinders shall be tested in accordance with AASHTO T-277. If the average coulomb value for this test is less than the value shown in [Table 817.05](#), the lot will be accepted at the full contract unit price.

If the average test result exceeds the coulomb value in [Table 817.05](#), payment for PCC in that element (in-place cost) shall be reduced 0.005% for each coulomb above the coulomb value given in [Table 817.05](#). However, the reduction in price shall not exceed 5% of the bid price of the PCC. PCC with a coulomb value that exceeds the maximum allowed in [Table 817.05](#) by 1000 coulombs shall be rejected. However, bridge deck PCC with a coulomb value exceeding the maximum by over 1000 coulombs or more may be accepted by the Chief Engineer at 95% of the contract bid price provided it meets the minimum compressive strength requirement, and the Contractor applies an epoxy PCC overlay at his own expense. In such cases, deck grooving will not be required. Any adjustments to the roadway grade shall be made as required by the Chief Engineer at the Contractor's expense.

PCC abutments and pier caps with a coulomb value that exceeds the maximum required in [Table 817.05](#) by more than 1000 coulombs may be accepted at 95% of the contract

bid price provided that the compressive strength meets the contract minimum specified requirements and that the Contractor applies an approved epoxy overlay, at his expense.

The reduction in the bid price specified above shall be applied to the total volume of PCC in the bridge members (deck slab of a single span, deck slab of a group of continuous spans, pier or abutments), of which any portion of the PCC in the member did not meet the permeability test requirements.

Table 817.05-Colomb Requirements

<u>PCC Class Requirement</u>	<u>Approved Use(s)</u>	<u>Coulomb</u>
Class A Structural (Trap Rock)	Bridge- Decks, Sidewalks Approach Slabs, Medians For Superstructures, Suitable for all Class B Structural specified uses	1,500 Max
Class B Structural	Reinforced Structures- Footings, Beams, Girders, Columns, Piers, Abutments, Walls, Arched Ribs, Box Culverts, Pre-cast Piles, Traffic Barriers and Cribbing	2,000 Max.
Class H Lightweight	As Specified	1,500 Max.

817.06 CONSTRUCTION METHODS.

Aggregates and portland cement shall be proportioned by weight; water may be proportioned by volume or by weight. Batch weights of aggregates for the concrete shall be corrected for free moisture, as calculated from moisture determination performed by the Contractor. These moisture determinations shall be made at a minimum of every 4 hours PCC consistency shall be checked in accordance with [501.15](#).

All tolerances for measurement of materials will be applied to the approved mix design quantities. Tolerances for proportioning are as follows:

Material	Tolerance, Percent by Weight of Mix Design
Cement	+4,-0
Coarse Aggregate	±2
Fine Aggregate	±2
Water	±1
Admixtures	±3

The approved mix design shall not be changed except as provided below:

- (1) Adjustment for variation in fineness modules (FM). If the FM of the fine aggregate exceeds the limits specified in [803.01](#), the mix design shall be adjusted as provided in [817.04](#).
- (2) Adjustments for new materials. Change in source or character of the materials shall be made only after tests on trial mixes and with the Chief Engineer's written approval.