PORTLAND CEMENT (PC) CONCRETE PROPORTIONS

GENERAL

Materials for pavement concrete and structural concrete shall be mixed in any one of the following proportions for the class of concrete specified. Each mixture will have specific requirements for the coarse and fine aggregates and the type of cement. Concrete mix proportions include the unit volumes of all materials.

Mix numbers designate numerous aspects of the particular mix. The following is an explanation of the various aspects of the mix number:

- The first letter designates the class of concrete as designated in the contract documents.

- In certain mix designations, the letter V or L appears after the first hyphen. This indicates either Class V or Class L aggregate is to be used. If no letter is shown, aggregate other than Class V or Class L shall be used.

- The number indicates the relationship of coarse aggregate to fine aggregate. A mix with a 4 is a 50/50 mix. The following chart shows the number within the mix number and the proportions of the aggregates for each number:

2	is composed of 40% fine and 60% coarse
3	is composed of 45% fine and 55% coarse
4	is composed of 50% fine and 50% coarse
5	is composed of 55% fine and 45% coarse
6	is composed of 60% fine and 40% coarse
7	is composed of 65% fine and 35% coarse
8	is composed of 70% fine and 30% coarse
57	is composed of 50% fine and 50% coarse
57-6	is composed of 60% fine and 40% coarse

- The letters WR indicate water reducer is used in this mixture.

- When a C or an F is shown toward the end of the mix number, fly ash is a part of the mixture and C-fly ash or an F-fly ash, respectively, is used. The percentage of fly ash being used in the mixture shall be designated at the end of the mix number.

- When used as a mineral admixture, Ground Granulated Blast Furnace Slag (GGBFS) shall be designated through the letter “S,” followed by the percent substitution, and shown at the end of the mix number. This would be in the same convention used for fly ash substitution. When GGBFS is a portion of a blended cement, the cement type will be designated as IS, but special notation will not be made in the mix number.

- The following example illustrates a mix number showing a Class C concrete mixture, 50/50 aggregate proportions, using Class L aggregate, water reducer, and 35% GGBFS substitution.

Example: C - L 4 W R – S35

The following example illustrates a mix number showing a Class C concrete mixture, 50/50 aggregate proportions, using water reducer and a Class C fly ash substitution at a rate of 10%.

Example: C – 4 W R – C10

The following example illustrates a mix number showing a Class C concrete mixture, 50/50 aggregate proportions, using a water reducer, Class C fly ash substitution at 20%, and GGBFS substitution at 20%.

Example: C – 4 W R –C20-S20

The Class D mixtures and the Class V mixtures vary somewhat from the above pattern, but follow the general format.

MIX REQUIREMENTS

General requirements for the mixes are:

1. Fly Ash and GGBFS used in concrete mixtures shall meet the requirements of Section 4108. Fly Ashes for use in concrete mixtures shall be included on the list of approved sources (Materials IM 491.17). GGBFS for use in concrete mixtures shall be included on the list of approved sources (Materials IM 491.14).

2. A water-reducing admixture shall be used in concrete mixtures with the designation as follows: Those mixtures have mixture numbers which have the letters "WR" following a single digit number, all following the first hyphen in the mixture number. These mixtures have reduced cementitious contents to produce concrete of approximately equal strength compared with other mixtures in a particular class of concrete. A water-reducing admixture may be added to other concrete mixtures, without cement reduction, to aid in workability and air entrainment. Other admixture combinations may be approved based on manufactures recommendations.

   The water-reducing admixture shall meet the requirements of Section 4103 and shall be included on the list of Approved Sources of Water Reducing Admixtures (Materials IM 403, Appendix C). The dosage shall be as described in IM 403.

3. The total quantity of water in the concrete, including water in the aggregate, shall not exceed the maximum water to cement and fly ash ratio.

4. Type I, Type II, Type III, Type IP, and Type IS Cement shall be used as provided for in the specifications. All cement shall be from an approved source as per IM 401. The cement type shall be documented on all reports pertaining to a project.

5. The fine aggregates other than Class V (Section 4117) and Class L (Section 4111) shall meet the requirements of Section 4110 of the current specifications. The coarse aggregates for mixtures using aggregates other than Class V aggregates and excluding Class O concrete (Section 4115.05) mixtures shall meet the requirements of Articles 4115.01 through 4115.04 of the current specifications. Intermediate aggregates used for QMC, BR,

or HPC-D mixes shall meet 4112. Aggregates meeting 4112 may be substituted for 4110.

6. When approved by the Engineer, combined fine and coarse aggregate may be used in combination with screened coarse aggregate to produce proportions specified for Class D and Class X concrete mixtures according to the percentage of particles passing the No. 4 sieve in the combined aggregate at the time the material is used.

7. With Engineer approval, proportions designated for mixtures A-V, B-V or C-V with and without fly ash may be substituted for Class X concrete.

8. With Engineer approval, Class M concrete may be substituted for Class A, Class B or Class C concrete.

A-MIX

A-Mixes are specified primarily as paving mixes. They have a lower cement content and lower ultimate strength when compared to a Class C-Mix. A-Mix is commonly used on lower traffic roadways.

B-MIX

B-Mixes are specified primarily as paving mixes. They have the least amount of cement of any paving mix. The strength is also lower than for other paving mixes. B-Mix is commonly used on sidewalks and trails.

C-MIX

C-Mixes are specified for use in both paving and structures. It is the normal paving mix used in primary paving. Typical structural uses would include box culverts, bridge piers, bridge abutments, and most bridge decks.

D-MIX

D-Mixes are specified for use primarily in structures. A typical use includes drilled shafts.

M-MIX

M-Mixes are designed for high early strength, suitable for many applications for which they are allowed. Calcium chloride should only be used when needed, for patching and other placements without steel reinforcement. Do not include water in calcium chloride solution when calculating water cement ratio.

O-MIX

O-Mixes are specified for low slump concrete, primarily for use in bridge deck overlays. The water-cement ratio is intended to be controlled by the slump specified elsewhere for concrete where these mixtures are used. A water-reducing agent is required for this mix , as described in IM 403. O-Mixes require coarse aggregate specifically intended for repair and overlay. See Article 4115.05. HPC-O is also used in bridge deck overlays. The HPC-O mix requires the use of blended cements, slag, and fly ash. The maximum water-cement ratio is 0.42.

X-MIX

X-Mixes are specified to be used as seal course concrete, primarily in cofferdams. No air entraining is required. No maximum water-cementitious ratio is specified. See Article 2405.05 for limits on water usage.

QMC

Contractor-designed aggregate proportioning mixes for paving. Minimum absolute volume of cement is 0.106. Maximum water-cement ratio is 0.45.

BR

BR mixes are used in slip form barrier rail in accordance with Section 2513. Required designed aggregate proportioning. The minimum absolute volume of cement is 0.114. The basic water-cement ratio is 0.40 and the maximum water-cement ratio is 0.45.

HPC

HPC mixes are used in bridge substructures and decks to achieve low permeability and higher compressive strength. The use of blended cements, slag, or Class F fly ash is required with these mixes. Class C fly ash may also be substituted. Maximum water-cement ratio is 0.42 for decks and 0.45 for substructures. Aggregate proportioning is required for HPC-D mixes with an absolute volume of cement of 0.118.

CLASS V

Class V is an aggregate classification, specified in Section 4117. The fine limestone aggregates in concrete mixes using Class V aggregate with/without fly ash shall meet the requirements of Article 4117.03 of the current specifications. Allowable cements and substitutions shall meet the requirements of Article 4117.05. This material may be used in various concrete mixes, including HPC mixes. The mixes utilizing this material will be designated with a Roman numeral V, in the Mix Number.

CLASS L

Class L is an aggregate classification, specified in Section 4111. This material may be used in various concrete mixes, so designated. The mixes utilizing this material will be designated with a Roman numeral L, in the Mix Number.

FLY ASH & GGBFS SUBSTITUTION

At Contractor option, fly ash or GGBFS may be substituted for a portion of the cement in concrete mixes, within the limitations set forth in the appropriate Article for each type of placement. IM 527 gives instructions on how to determine the proper batch proportions in a mix. When fly ash or GGBFS is substituted for the cement, the replacement shall be on a pound-for-pound (kilogram-for-kilogram) basis. Tables 1, 2, and 3 define concrete mixes with no substitution. These mixes shall be used as the basis for determining the final batch proportions and shall be adjusted accordingly. The change in volume resulting from the substitution shall be determined and an adjustment in both coarse and fine aggregate proportions shall be determined in order to ensure a unit volume. The change in aggregate proportions shall be in the same ratio as that of the specific mix. In those cases where the cement content is increased, relative to the standard design mix, the mix proportions shall be adjusted and a change in the aggregate content shall be determined, as described above.

When both fly ash and GGBFS are substituted for the cement in ready-mixed concrete, the replacement shall be on a pound-for-pound (kilogram-for-kilogram) basis and shall be substituted as shown in the following example.

Example: C-3WR-C20-S20

Absolute Volume Cement = 0.108

Cement = 0.108 X 62.4 X 27 X 3.14 = 571 lbs per cubic yard

Fly ash substitution 20% = 571 X 0.20 = 114 lbs per cubic yard

Slag substitution 20% = 571 X 0.20 = 114 lbs per cubic yard

Type IP and Type IS cements shall be considered cement with regard to substitution of fly ash. Refer to appropriate Article for limitations. A Type IS(25) cement with a 20% fly ash replacement is equivalent to a 40% weight replacement of Portland cement.

Example: C-3WR-C20 using Type IS(20) cement

Absolute Volume Cement = 0.108

Cement = 0.108 X 62.4 X 27 X 3.10 = 564 lbs per cubic yard

Fly ash substitution 20% = 564 X 0.20 = 113 lbs per cubic yard

Weight of cement = 564 – 113 = 451 lbs per cubic yard

Type IS(20) cement contains Portland cement and slag

451 x 0.80 = 361 lbs Portland cement
451 X 0.20 = 90 lbs slag

Total replacement of Portland cement
((113 + 90) / 564) X100 = 36%

Proportion Table 1
Concrete Mixes
Using Article 4110 and 4115 Aggregates
Basic Absolute Volumes of Materials Per Unit Volume of Concrete

A MIXES Basic w/c = 0.474 Max w/c = 0.532

Mix No.	Cement	Water	Air	Fine	Coarse
A-2	0.101	0.150	0.060	0.276	0.413
A-3	0.104	0.155	0.060	0.306	0.375
A-4	0.108	0.161	0.060	0.335	0.336
A-5	0.111	0.165	0.060	0.365	0.299
A-6	0.115	0.171	0.060	0.392	0.262

B MIXES Basic w/c = 0.536 Max w/c = 0.600

Mix No.	Cement	Water	Air	Fine	Coarse
B-2	0.088	0.148	0.060	0.282	0.422
B-3	0.091	0.153	0.060	0.313	0.383
B-4	0.093	0.157	0.060	0.345	0.345
B-5	0.096	0.162	0.060	0.375	0.307
B-6	0.099	0.167	0.060	0.404	0.270
B-7	0.102	0.172	0.060	0.433	0.233
B-8	0.105	0.177	0.060	0.461	0.197

C MIXES Basic w/c = 0.430 Max w/c = 0.488

Mix No.	Cement	Water	Air	Fine	Coarse
C-2	0.110	0.149	0.060	0.272	0.409
C-3	0.114	0.154	0.060	0.302	0.370
C-4	0.118	0.159	0.060	0.331	0.332
C-5	0.123	0.166	0.060	0.358	0.293
C-6	0.128	0.173	0.060	0.383	0.256

C-WR MIXES Basic w/c = 0.430 Max w/c = 0.489

Mix No.	Cement	Water	Air	Fine	Coarse
C-3WR	0.108	0.146	0.060	0.309	0.377
C-4WR	0.112	0.151	0.060	0.338	0.339
C-5WR	0.117	0.158	0.060	0.366	0.299
C-6WR	0.121	0.163	0.060	0.394	0.262

D MIXES Basic w/c = 0.423 Max w/c = 0.450

Mix No.	Cement	Water	Air	Fine	Coarse
D-57	0.134	0.178	0.060	0.314	0.314
D-57-6	0.134	0.178	0.060	0.377	0.251

M MIXES Basic w/c = 0.328 Max w/c = 0.400

Mix No.	Cement	Water	Air	Fine	Coarse
M-3	0.149	0.153	0.060	0.287	0.351
M-4	0.156	0.161	0.060	0.311	0.312
M-5	0.160	0.165	0.060	0.338	0.277

O MIXES Basic w/c = 0.327 Max w/c = ------

Mix No.	Cement	Water	Air	Fine	Coarse
O-4WR	0.156	0.160	0.060	0.312	0.312

Basic w/c = 0.370 Max w/c =0.420

HPC-O	0.134	0.156	0.060	0.325	0.325

HPC MIXES Basic w/c = 0.420 Max w/c =0.450

HPC-S	0.118	0.156	0.065	0.330	0.331

X MIXES Basic w/c = 0.423 Max w/c = ------

Mix No.	Cement	Water	Air	Fine	Coarse
X-2	0.124	0.165	0.000	0.284	0.427
X-3	0.129	0.171	0.000	0.315	0.385
X-4	0.134	0.178	0.000	0.344	0.344

Above mixtures are based on Type I or Type II cements (Sp. G. = 3.14). Mixes using blended cements (Type IP or IS) must be adjusted for cement gravities listed in IM 401.

Proportion Table 2
Concrete Mixes
Using Class V Aggregates Combined with Limestone
Basic Absolute Volumes of Materials Per Unit Volume of Concrete

V47B MIXES

Mix No.	Cement	Water	Air	Class V.	Coarse Limestone	Basic w/c	Max. w/c
A-V47B	0.107	0.148	0.060	0.479	0.206	0.440	0.560
B-V47B	0.098	0.160	0.060	0.477	0.205	0.520	0.597
C-V47B[1]	0.107	0.148	0.060	0.479	0.206	0.440	0.560*
C-V47BF[2]	0.114	0.141	0.060	0.479	0.206	0.420	0.488*
M-V47B[3]	0.155	0.170	0.060	0.338	0.277	0.350	0.400

V MIXES

Mix No.	Cement	Water	Air	Class V.	Fine Limestone	Basic w/c	Max. w/c
A-V	0.135	0.188	0.060	0.586	0.031	0.444	0.467
B-V	0.135	0.188	0.060	0.586	0.031	0.444	0.467
C-V	0.135	0.188	0.060	0.586	0.031	0.444	0.467
M-V	0.160	0.196	0.060	0.555	0.029	0.390	0.420

CV-HPC MIXES

Mix No.	Cement	Water	Air	Class V.	Coarse Limestone	Basic w/c	Max. w/c
CV-HPC-D	0.126	0.158	0.060	0.361	0.295	0.400	0.420
CV-HPC-S	0.126	0.166	0.060	0.356	0.292	0.420	0.450

Above mixtures are based on Type I or Type II cements (Sp. G. = 3.14). Mixes using blended cements (Type IP or IS) must be adjusted for cement gravities listed in IM 401.

*The maximum w/c shall be 0.450 when used in concrete pavement.
[1]C-V47B mix shall be used when Type I/II cements are used with Class F fly ash or ggbfs.
[2]C-V47BF mix shall be used when Type IP or Type IS cements are used.
[3]M-V47B mix shall use Type I/II cements for patching projects.

Proportion Table 3
Concrete Mixes
Using Class L Aggregates
Basic Absolute Volumes of Materials Per Unit Volume of Concrete

A-L MIXES Basic w/c = 0.474 Max w/c = 0.532

Mix No.	Cement	Water	Air	Fine	Coarse
A-L-2	0.107	0.159	0.060	0.270	0.404
A-L-3	0.111	0.165	0.060	0.299	0.365
A-L-4	0.115	0.171	0.060	0.327	0.327
A-L-5	0.118	0.176	0.060	0.355	0.291

B-L MIXES Basic w/c = 0.536 Max w/c = 0.600

Mix No.	Cement	Water	Air	Fine	Coarse
B-L-2	0.094	0.158	0.060	0.275	0.413
B-L-3	0.097	0.163	0.060	0.306	0.374
B-L-4	0.099	0.167	0.060	0.337	0.337
B-L-5	0.102	0.172	0.060	0.366	0.300

C-L MIXES Basic w/c = 0.430 Max w/c = 0.488

Mix No.	Cement	Water	Air	Fine	Coarse
C-L-2	0.117	0.158	0.060	0.266	0.399
C-L-3	0.121	0.163	0.060	0.295	0.361
C-L-4	0.125	0.169	0.060	0.323	0.323
C-L-5	0.131	0.177	0.060	0.348	0.284

C-LWR MIXES Basic w/c = 0.430 Max w/c = 0.489

Mix No.	Cement	Water	Air	Fine	Coarse
C-L3WR	0.115	0.155	0.000	0.301	0.369
C-L4WR	0.119	0.161	0.000	0.330	0.330
C-L5WR	0.124	0.167	0.000	0.357	0.292

Above mixtures are based on Type I or Type II cements (Sp. G. = 3.14). Mixes using blended cements (Type IP or IS) must be adjusted for cement gravities listed in IM 401.