

# Permeability of Concrete

*Concrete permeability is the ability for liquids and gases to pass throughout the concrete matrix through the interconnecting void of spaces inherent to concrete. The void structure, and therefore the permeability, is affected by the materials incorporated into the concrete mixture. The leaching of water soluble calcium hydroxide produced by the hydration of portland cement can be a significant contributor to the formation of voids.*

## How Does the Degree of Permeability Affect Concrete?

Most of the factors which lead to lack of concrete durability involve the permeation of the concrete by liquids from external sources. Typical causes of concrete failure include:

- Chemical attack by aggressors such as:
  - ~ Sulfate environments (e.g. marine areas, wastewater, certain groundwater)
  - ~ Alkali-aggregate reaction (activated by moisture and alkalis)
  - ~ Acids and salts (e.g. de-icing salts)
  - ~ Chlorides
- Corrosion of steel reinforcement
- Freeze/thaw damage

The ability of concrete to resist these types of degradation is directly related to its impermeability. If harmful substances are prevented from entering the concrete, damage will occur and the life of the structure may be extended. For further information on producing durable concrete, see ACI 201, "Guide to Durable Concrete."

## How Can Permeability Be Lowered?

The judicious use of a pozzolan such as Boral Fly Ash will enhance the concrete's ability to withstand the deleterious effects of its surroundings. A pozzolan will chemically react with calcium hydroxide to produce additional cementitious compounds which densify the cement matrix and fill the capillaries which causes refinement of pore size distribution in all

concrete. The lower water demand of fly ash concrete also contributes to the reduction of water pockets at the cement/aggregate interface. For these reasons, properly designed, mixed, placed, and cured concrete incorporating a pozzolan results in greater impermeability and a cementing matrix more resistant to chemical attack. Recent research indicates that the most impermeable concrete demands the use of a pozzolan. As determined by ASTM C 1202, "Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration," and AASHTO Test Method T-277, "Rapid Determination of the Chloride Permeability of Concrete," fly ash concrete with superplasticizers can produce ratings classified as "very low". This compares with a permeability rating of "moderate" with comparable concretes using high contents of portland cement with superplasticizers.

While the permeabilities of concretes without superplasticizers are not as low, there is a substantial reduction in the permeability attributable to the use of fly ash when compared with strength concretes containing portland cement only.

Research conducted at the University of Texas at Austin, Balcones Research Center compared the effects on permeability of common concrete ingredients. The chart on the reverse side demonstrates test results from a study of concretes containing fly ash, silica fume, ground granulated blast furnace slag, portland cement and a superplasticizer.

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### Batch Weights (in lb./yd<sup>3</sup>)

Mix #	Portland Cement	F1	Fly Ash F2	C	Silica Fume	GCBFS	Coarse Aggregate	Fine Aggregate
1	500	0	0	0	0	0	1,691	1,691
2	600	0	0	0	0	0	1,691	1,662
3	425	100	0	0	0	0	1,691	1,702
4	425	200	0	0	0	0	1,691	1,601
5	425	300	0	0	0	0	1,691	1,403
6	425	0	100	0	0	0	1,691	1,718
7	425	0	200	0	0	0	1,691	1,617
8	425	0	300	0	0	0	1,691	1,382
9	425	0	0	100	0	0	1,691	1,658
10	425	0	0	200	0	0	1,691	1,627
11	500	0	0	0	50	0	1,691	1,643
12	500	0	150	0	50	0	1,691	1,488
13	250	0	0	0	0	250	1,691	1,663
14	600	200	0	0	0	0	1,691	1,359
15	300	300	0	0	0	0	1,691	1,548

Properly designed fly ash concrete mixtures provide permeability ratings comparable to other pozzolans and supplemental materials and are manufactured with ingredients readily available at the concrete batch plant.

Consult your Boral representative for information on the source and class of fly ash nearest you. The Boral technical staff is prepared to assist you in developing the most durable concrete possible.

### Concrete Properties

Mix #	Slump (in)	w/c*	Comp 28 Day	Strength 56 Day	Chloride Perm.** (coulomb)
1	4.50	0.43	6,700	7,640	2,282
2	3.75	0.35	7,670	8,530	2,205
3	3.00	0.37	7,620	8,540	890
4	4.50	0.30	7,180	8,660	588
5	5.00	0.30	8,060	9,160	623
6	3.50	0.35	6,670	7,610	1,184
7	5.00	0.29	9,020	10,170	298
8	4.50	0.31	10,860	11,930	169
9	3.00	0.41	7,330	7,680	2,490
10	4.00	0.30	10,130	11,010	981
11	3.50	0.39	9,660	9,980	406
12	5.00	0.29	11,720	12,150	171
13	5.00	0.47	7,190	8,080	662
14	5.00	0.28	8,610	9,790	693
15	4.00	0.33	5,830	6,890	756

\*w/c is water-cementitious ratio \*\*Average of two specimens 28 day moist cure = 28 day cure in lab air All mixes contain ASTM C 494 Type F Superplasticizer at 12 oz/cwt. of cementitious material

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