Permeability

OF HIGH REACTIVITY METAKAOLIN CONCRETE

High Reactivity Metakaolin (HRM) is an engineered, high-strength, pozzolanic material. It is an economical alternative to silica fume and can be utilized in high performance concrete.

Permeability is defined as the coefficient representing "the rate at which water is transmitted through a saturated specimen of concrete under an externally maintained hydraulic gradient."[1] Permeability is inversely linked to durability in that the lower the permeability, the higher the durability of concrete, and "the permeability of concrete to water and chloride is the major factor affecting the process of corrosion of embedded metals."[2]

Permeability is most frequently described by the chloride-ion permeability test that measures the passage of electrical current through a concrete specimen exposed to a solution of sodium chloride. Limits of acceptability are as shown in the table to the right.[3]

Permeability of concrete and the resulting level of durability are matters of great concern to designers of concrete structures. High Reactivity Metakaolin (HRM) can be a superior tool in reducing permeability.

Chloride Permeability Based on Charge Passed

Charge Passed (coulombs)	Chloride Permeability	Typical of
>4,000	High	High water/cement ratio (>0.6), PCC
2,000 – 4,000	Moderate	Moderate water/ cement ratio (0.4 to 0.5), PCC
1,000 – 2,000	Low	Low water/cement ratio (<0.4), PCC
100 – 1,000	Very Low	Latex-modified concrete, silica-fume concrete
<100	Negligible	Polymer impregnated concrete, polymer concrete

All numbers as % by weight

For more information or answers to questions about the use of fly ash in specific applications, contact your nearest Boral Resources Technical Sales Representative or call 1-770-684-0102

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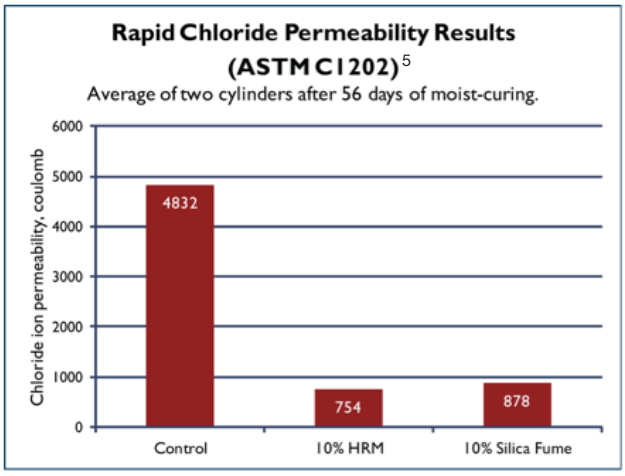
Recent testing has shown that properly proportioned concretes using HRM as a direct replacement for silica-fume, along with a combination of high-range water reducing and air-entraining admixtures, have the ability to produce the same low levels of permeability as latex modified and silica fume concrete.

Using HRM in the concrete mix greatly aids permeability and durability in the following ways:

1. Through pozzolanic activity, HRM chemically combines with water and calcium hydroxide, forming additional cementitious compounds that result in denser, higher strength concrete. The calcium hydroxide chemically combined with HRM is not subject to leaching, thereby helping to maintain high density.
2. The conversion of soluble calcium hydroxide to cementitious compounds decreases bleed channels and void spaces and thereby reduces permeability.
3. At the same time, the above chemical reaction reduces the amount of calcium hydroxide susceptible to attack by weak acids and salts.
4. Concrete density is also increased by the small, finely divided particles of HRM that act like micro-aggregates to help fill in the tiniest voids in the concrete.
5. Alkali-silica reactivity (ASR) in concrete can induce expansion and cracking, increasing the concrete permeability. The expansion caused by ASR can be mitigated if a portion of the portland cement is replaced by a suitable metakaolin.[4]



M.A. Caldarone, K.A. Gruber and R.G. Burg, "High Reactivity Metakaolin: A New Generation Admixture", American Concrete Institute, *Concrete International*, November 1994.

1 "Admixtures for Concrete", American Concrete Institute, Journal of ACI Proceedings, Vol. 60, No. 11, November 1963, p. 1512.
2 "Guide to Durable Concrete", ACI 201.2R-92, American Concrete Institute, Section 4.4.2, April 1992.
3 Suprenant, Bruce A., "Testing for Chloride Permeability of Concrete", Concrete Construction, July 1991.
4 G.V. Walters and T.R. Jones, "Effect of Metakaolin on Alkali-Silica Reaction (ASR) in Concrete Manufactured with Reactive Aggregate", American Concrete Institute, SP-132, Durability of Concrete: Second International Conference Montreal Canada, 1991.
5 M.A. Caldarone, K.A. Gruber, and R.G. Burg, "High Reactivity Metakaolin: A New Generation Mineral Admixture", American Concrete Institute, Concrete International, November 1994.