BCRC
Building & Construction
Research & Consultancy

BRC (NSW) Pty Ltd
ABN: 91 116 565 265

PO Box 10, Brookvale,
NSW, 2100
Tel 02 9939 7533
Fax 02 9939 7544
Mob 0419 44 3200
Email r.munn@bcrc.com.au

Correspondence Ref: BCRC-193

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KRYSTOL AUSTRALIA
PO Box 3032
Kirrawee NSW 2232

Att. Aaran Duncan

Review of Krystol Internal Membrane (KIM) on Concrete Properties

Two of the BCRC directors, Marton Marosszeky and Robert Munn, have substantial experience in assessment and application of permeability reducing admixtures for concrete.

As requested, we have completed a review of the testing data you provided and examined the certificates to which you referred via the Internet. A brief summary report is presented below regarding the effects of KIM on concrete properties. KIM appears to meet the requirements of a Type SN admixture AS1478.1 based on Boral's data undertaken in 2006, but it also appears to be a Type SRe admixture based on most overseas test data. This difference can be explained by different cements and admixtures used in other countries.

The range of the test programs that have been reviewed are set out below. In all applications, KIM was consistently added to concrete at either 1.5% or 2% by mass of cementitious materials and thus the actual dosage rate is not repeated in the text.

Various certificates issued for KIM

- In September 2005, KIM was certified by ICC Evaluation Service (ESR-1515) as a Chemical Admixture for use in Concrete
- KIM was certified for waterproofing concrete drinking water containment structures by NSF International
- In March 2005, KIM-HS has been tested extensively and approved by BBA for its intended use in concrete (Certificate No 05/4217)
- Based upon the Twining testing data, KIM conforms to ASTM C494 (Type D) requirements except for a slightly extended setting time (Twining 2005).
- KIM acted as effective water reducing and setting retarding admixture complying with the requirement of Canadian standard CAN/CSA A266.2-M except for extended setting time. (HBT AGRA 1993).

Effect on plastic properties of concrete

The addition of KIM is claimed to improve workability and pumpability. When cement content and W/C ratio remained constant, the addition of KIM increased the slump by 13% and the air content by 1.4% compared with plain concrete. The initial and final setting times of KIM-treated concrete were one hour longer than that for the control concrete (Boral 2006).

KIM used alone can have water-reducing and set-retarding properties especially extended setting time (Twining 2005 and HBT AGRA 1993) and an air-entraining role in concrete (HBT AGRA 1993). Accordingly dosages of other admixtures used in the same concrete could be reduced. However, trial batches to assess the actual concrete properties are highly recommended.

For concretes with the same cement content, the addition of KIM reduced water demand by 5% (WJE 2003). Improved quality concrete is thus expected to result from the inclusion of KIM in the mix design.

Effect on strength of hardened concrete
With respect to the effect on concrete strength development, KIM-treated concrete was compared with the control concrete in two ways. If water or W/C ratio remained constant, KIM-treated concretes were found to have marginally increased compressive strength (Boral 2006). On the other hand, if water demand in KIM-treated concrete was reduced to achieve equal slump, the 28-day test data showed that the KIM treated concrete had 9% greater compressive strength and 6% higher flexural strength (WJE 2003). Similar strength gain has been confirmed by Twining laboratory testing (Twining 2005).

Effect on drying shrinkage of concrete
KIM treated concretes show reduced drying shrinkage compared with plain concretes. For concretes made with GB cement and equal W/C ratio, the addition of KIM resulted in 4% reduction in unrestrained drying shrinkage compared to control mixes (Boral 2006). When SL cement was used, the KIM treated concrete had a 19% reduction in unrestrained drying shrinkage in comparison to the control concrete containing water reducing and air entraining admixes (Boral 1995).

Effect on permeability of concrete
KIM treated concrete showed lower water permeability than control concrete tested by DIN-1048 when concrete samples are subjected to hydrostatic pressure of 72.5psi for 72 hours. In comparison with the control concrete using same GB cement content and W/C, the addition of KIM resulted in reduction in water permeability of 13% (Boral 2006). For equal cement and slump, the KIM-treated concrete had a 57% reduction compared with the control concrete (AGRA 1995).

KIM treated concrete exhibited low water permeability even under hydrostatic pressure of 200psi for 14 days as per the US Army Corps of Engineers CRD C48-92, “Standard Test Method for Water Permeability of Concrete”. The KIM treated samples showed no water penetration through samples but in contrast the control samples failed in 45 hours (University of British Columbia 2003).

KIM treated concrete has been compared with Xypex C-1000NF in terms of water permeability. When tested to US Army Corps of Engineers Test Method CRD C48-73, Xypex C-1000NF treated concrete showed no water leakage subjected to a hydrostatic pressure of about 102psi for 14 days according to the data sheet for Xypex C-1000NF. Because of the differences in test methods and pressures, it is therefore not possible to conclude, which material has superior performance without independent verification.

Chloride resistance
The AASHTO T277 test method measures resistance to chloride penetration under electrical potential difference. This test is widely accepted to assess the concrete chloride resistance. The KIM treated concrete has been shown to reduce the charge passed by 35% on 28-day concretes and by 45% on 90-day concretes in compared with the control mix at same W/C ratios (NY & NJ 1998).

Effect on self-healing cracks in concrete
The inclusion of KIM is claimed to accelerate the crack-healing. It took about 500 hours for KIM treated concrete to heal its crack of 0.3mm in comparison with about 1200 hours for the control

concrete. Moreover, with the addition of KIM, even a crack width of 0.6mm was sealed after about 1300 hours (CBI 2003).

Effects on AVPV of concrete
AVPV value is an indicator of good quality concrete. When cement content and W/C ratio remained constant, the control concrete had an AVPV of 14.1%. In contrast, KIM-treated concrete had an AVPV value of 13.2%, that is a reduction of 6% (Boral 2006).

Considering all the above, it is of our opinion that KIM is an appropriate permeability reducing admixture for concrete for basements, swimming pools, roofs and other similar structures provided manufacturer's instructions are followed. It enhances concrete properties as follows.

- Workability (showing only a slight increase in setting time and suitable for concrete practices)
- It has no detrimental effects on compressive and flexural strength development of concrete.
- All data show a reduction in the unrestrained drying shrinkage with the inclusion of KIM.
- Water permeability tests by Boral and overseas sources show it has effectively reduced concrete permeability.
- Permeability test results show KIM to be comparable with Xypex C1000NF as concretes tested in a similar manner with both products showed no leakage.
- Chloride resistance test results show that KIM makes concrete more hydrophobic and thus more durable.

In summary, with the addition of KIM to the concrete mix at the rates recommended by the manufacturer there appear to be no deleterious effects on the plastic and harden states of concrete whilst modifying the concrete to have better durability, lower permeability, increased strength and lower drying shrinkage. In our opinion KIM appears to have similar performance in concrete to Xypex C-1000NF based on all the relevant testing from overseas and in Australia to date.

I would be pleased to amplify these findings as required.

Bob Munn
Managing Consultant
Construction Materials
and Applications

Reference

[1] ICC Evaluation Service report, ESR-1515, 2005
[2] NSF certificate, 2004
[3] BBA certificate, 2005
[4] Twining 2005 Ref 40#
[5] HBT AGRA 1993 Ref 04#
[6] Boral 2006, cement
[7] WJE 2003 Ref 37#
[8] Boral 1995 Ref 51#,
[9] AGRA 1995 Ref 12#
[10] UBC 2003 Ref 24#
[11] NY & NJ 1998 Ref 32#
[12] CBI 2003 Ref 77#