XYPEX INDEPENDENT TESTING SUMMARY

XYPEX TESTING

We appreciated the importance and value of testing the performance as well as the quality of the unique Xypex products and technology. Xypex products have been tested for an extensive variety of **performance** criteria as well as for **quality assurance** by **independent accredited laboratories** throughout the world. Testing includes: water permeability, chemical permeability, petroleum / gas permeability, air permeability, sealing cracks, chemical resistance, freeze-thaw durability, radiation resistance, compressive strength, tensile bond, abrasion resistance, potable water and public health testing. Xypex have also evaluated related factors associated with crystalline growth; include porosity and scanning electron microscopy. The following is an executive summary of some of the independent testing which the Xypex product and technology has undergone. Copies of the full test reports are available upon request.

SELECT ABSTRACTS OF INDEPENDENT TESTING OF XYPEX PRODUCTS AND TECHNOLOGY

WATER PERMEABILITY TESTING

U.S. Army Corps of Engineers (USACE) CRD C48-*73 "Permeability of Concrete"*, Pacific Testing Labs, Seattle, USA PERM-100

Two inch (51mm) thick, 2000 psi (13.8MPa) concrete samples were pressure tested for water permeability up to a 405 ft. (124m) water head (175 psi / 1.2MPa), the limit of the testing apparatus. While untreated samples showed marked leakage, the Xypex Concentrate treated samples (as a result of the crystallization process) became totally sealed and exhibited no measurable flow through the sample.

U.S. Army Corps of Engineers (USACE) CRD C48-*73 "Permeability of Concrete"*, Warnock Hersey Lab, Vancouver, Canada PERM-101

Samples measuring 6 x 3 inches (150 x 74mm) were cast utilizing 3000 psi (20.7MPa) concrete. Following application and curing of the Xypex Concentrated treatment, the samples were placed into sealed vessels for water permeability testing. The maximum pressure of this particular apparatus of 180 psi (1.24MPa) was attained and it can be concluded that the samples treated with Xypex did not show any permanence or leakage.

U.S. Army Corps of Engineers (USACE) CRD C48-73 *"Permeability of Concrete",* Setsco Services, Pte. Ltd, Singapore PERM-103

Six Xypex Admix-treated and six untreated concrete samples were tested for water permeability. Pressure was applied in increments over seven days and then maintained at 7 bars (224 ft. head of water) for 10 days. The six reference samples showed water flowing through the sample beginning on the fifth day and increasing throughout the test period. In contrast, the Xypex Admix samples showed no water permeation at any time during the test.

U.S. Army Corps of Engineers (USACE) CRD C48-73 *"Water Permeability Test"*, Texas Construction Company - In House Test Report, Texas, U.S.A. PERM-104

Concrete samples containing the Xypex Admix were compared to control samples containing no Admix in tests to determine water permeability. Concrete cores 3/4" (19 mm) thick were made from 3000 psi (20.7MPa) concrete. Pressure utilizing a test apparatus was exerted on all of the samples. The control sample was totally saturated within 24 hours at 43 psi (0.3MPa). The core samples containing the Xypex Admix were tested at various levels of pressure over time. After 120 hours and a maximum pressure of 172 psi (1.2MPa), the Xypex samples showed no observable water permeation.

U.S. Army Corps of Engineers (USACE) CRD C48-*73 "Permeability of Concrete"*, Civil Engineering Department - Hosei University, Tokyo, Japan PERM-107

Three concrete cylinders (10cm diameter and 10cm high) were coated with Xypex Concentrate on their top surface; three other identical cylinders were not coated for references purposes. Following 28 days, the Xypex coating was removed. The concrete mix design incorporated 4.4% air content with a water/cement ratio of 0.63. All specimens were cured for 4 weeks prior to permeability testing. All samples were exposed to a water pressure of 10kgf / cm2. The discharge rate for the Xypex treated specimens averaged 0.27 (10^{-4} cc/sec), while the discharge rate for the untreated specimens averaged 9.7 (10^{-4} cc / sec). The mean permeability factor of the Xypex treated samples is below 3.8 (10^{-4} cc/sec) which is classified as very good. The untreated sample results were averaged at 115 x 10^{-12} m/s which is typically classified as poor.

ACCI Water Permeability Test, *"Water Permeability of 32 MPa Concrete Containing Admix C-1000NF / C-2000NF"*, Australia Centre of Construction and Innovation, University of New South Wales, Sydney, Australia PERM-110

Concrete samples containing Xypex Admix C-1000NF and C-2000NF at various dosage rates (0.8% and 1.2%) were tested for water permeability against control samples. Samples varied from GP type concrete to GB types (includes 20% fly ash). All 50 mm (2") thick samples were exposed to water pressure. Untreated GP samples showed leakage at 6 bars (60m / 200 ft. water head), while Xypex treated GP (1.2% Admix C-1000NF) samples showed no leakage at 10 bars (100m / 334 foot of water head). Water permeability coefficients were calculated and the Xypex Admix treated concrete showed significant reduction in water permeability by up to 93% at dosage rate of 0.8%. The GB (i.e. Fly Ash) concrete samples showed no leakage under 10 bars / 335 ft., samples were subsequently split transversely to determine depth of penetration according to the RTA water sorptivity test procedures using methylene blue indicator. The untreated samples showed 8mm (0.3") of penetration, while the Admix treated sample showed no penetration.

ACCI Water Permeability Test, *"Water Permeability of 40 MPa Concrete Containing Admix C-1000NF"*, Australia Centre of Construction and Innovation, University of New South Wales, Sydney, Australia PERM-111

Nine different commercial concretes (Grade 40MPa) were investigated in this test regime. There were three groups, including: plain cement (GP) with 25% fly ash replacement, blended cement with 38% slag and plain cement with 60% slag replacement. Samples containing Xypex Admix C-1000NF at 0.8% and 1.2% along with controls were cast for each concrete. All samples were exposed to 10 bars (100m / 334 foot of water head) at concrete age of 91 days. The 25% fly ash samples containing the Admix showed significant reduction in water permeability over the controls (e.g. permeability coefficient reduced by 70% to 93%). Since there was no leakage through any of the 38% slag samples, water penetration depths were determined using methylene blue indicator as per RTA sorptivity test procedures. In these samples the control had an average depth of penetration of 12.8mm (0.5"), while the Xypex treated samples showed 10.7mm (0.4") or 16% less penetration for the 0.8% dosed samples, while the 1.2% dosed sample had an average depth of penetration of 7.2mm (2.8") or 44% less than the controls. Water transmission rates for the 60% slag samples were higher than the other concretes, although the slag samples dosed with 1.2% Admix demonstrated a 39% reduction over the controls.

DIN 1048 *"Water Impermeability of Concrete",* Bautest - Corporation for Research & Testing of Building Materials, Augsburg, Germany PERM-200

Xypex-treated and untreated concrete samples 200 mm thick were pressure tested up to 7 bars (230 ft. / 70m water head) for 24 hours. The control samples measured water penetration up to a depth of 92mm while the Xypex-treated samples averaged 4mm, with one sample measuring zero.

Onorm B 3303 *"Sealing Effect Re Penetration of Water*", Technologisches Gerwerbemuseum, Federal Higher Technical Education & Research Institute, Vienna, Austria PERM-202

Xypex-treated concrete samples were pressure tested to a maximum 7 bars (230 ft. / 70m water head) for 10 days. Tests revealed that while 25ml of water had penetrated the untreated concrete samples, no measurable volume had penetrated the Xypex-treated samples. Test specimens were then broken and showed water penetration to a depth of 15mm on untreated samples but no measurable water penetration on the Xypex-treated samples.

GOST 12730.5 *"Evaluation of Water Tightness",* Orgenergostroi Public Corp., Center of Technology and Quality, Nuclear Power Stations, Engineering - Central, Construction Laboratory, Moscow, Russia PERM-206

Concrete cylinders were cast 150 x 150mm with a design water tightness figure of W2 (equal to 2 atmospheres according to standards of GOST 12730.5). Samples were moist cured for 28 days and then treated with 2 coats of Xypex Modified to a thickness of 1mm each. Control samples were also moist cured for 28 days. GOST 12730.5 test methodology is similar to the European DIN 1048 procedures in that water pressure is applied to the negative side of the cylinder samples and incrementally increased over time. Test results for the untreated control samples confirm a water tightness index of 2 atmospheres. The samples treated with the Xypex Modified had the following water tightness indices: 3 days – 4 atmospheres, 7 days - 7 atmospheres, 14 days - 8 atmospheres, and 28 days – 8 atmospheres. (Note - 1 atmosphere =14 psi or 32.4 ft. or 0.1MPa of head pressure).

GOST 12730.5 *"Evaluation of Water Tightness"*, Orgenergostroi Public Corp., Center of Technology and Quality, Nuclear Power Stations Engineering - Central Construction Laboratory, Moscow, Russia
PERM-207

Concrete cylinders were cast 150 x 150mm with a design water tightness of W2 or 2 atmospheres according to GOST 12730. Xypex Concentrate was applied to the samples at the rate of 1 kg per m^2. The samples were cured and the negative side of the cylinder was subjected to hydrostatic pressure for 14 days. The Xypex treated samples withheld a pressure of 12 atmospheres (168 psi / 389 ft. head pressure). There was an increased improvement in impermeability over the duration of the test. When a second coat (i.e. Modified) was applied on top of the hardened Concentrate coat the waterproofing effect was further enhanced. Testing was also performed on a Xypex Patch'n Plug installation. Concrete cylinders were cast 150 mm x 150 mm with a design water tightness of W2 or 2 atmospheres according to GOST 12730.5. A hole measuring 15 mm wide by 3 mm deep was cored into the surface of the cylinder. Xypex Patch n Plug was placed into this hole and firmly packed until hardened. The hole that was filled with Xypex Patch n Plug was then subjected to hydrostatic pressure as per GOST 12730.5-84. Test result confirmed that Xypex Patch n Plug repair material withstood 14 atmospheres of pressure (196 psi or 454 ft. head pressure).

DIN 1048 *"Evaluating Depth of Water Penetration under Pressure"*, Klokner Institute of the Czech Technical University, Prague, Czech Republic
PERM-208

Six 23MPa (3300 psi) concrete blocks (200 long x 100mm high); three with a 2-coat application of Concentrate + Modified and 3 untreated samples were subjected to positive-side water pressure. The pressure was increased incrementally over time (100kPa for 48 hours, 300kPa for 24 hours, and then 700kPa for 24 hours). All samples were then broken transversely to expose the depth of water penetration. The Xypex samples averaged a depth of 17 mm, while all he untreated samples showed water penetrated the entire thickness of the samples (i.e. 100mm).

STN 73 1321 *"Evaluating Water Tightness & Measurement of Water Penetration Under Pressure"*, Technical Testing Institute of Civil Engineering, Bratislava, Slovak Republic PERM-209

150mm thick concrete samples were prepared by an independent lab and the samples cast three Admix C-2000 treated samples and three samples with no Admix. Water pressure was incrementally increased to the samples and then samples were broken transversely to expose the depth of water penetration. The samples containing the Xypex Admix showed an average 27mm for the depth of water penetration. The non-treated samples showed an average penetration of 83mm.

LST 1330 *"Evaluation of the Effect of Xypex on Waterproofing",* Laboratory of Building Materials and Construction, Kaunas Technological University, Kaunas, Lithuania PERM-221

Concrete specimens were cast and tested by the laboratory of the Building Material's and Construction according to Lithuanian National Standards (LST). Control concrete was compared to Xypex Concentrate coated samples and concrete specimens containing Admix C-1000 (@ 3% by weight of the Portland cement content). All samples were exposed to water pressure over a prescribed 4 day period, starting at 0.1MPa (day 1 & 2), increasing to 0.3MPa (day 3) and then 0.7MPa (day 4). Upon the conclusion of the test the samples were split transversely and the depth of water permeation was measured. The 2 replicate control specimens had an average depth of penetration of 60 mm. The two replicate specimens coated with Xypex Concentrate had an average penetration depth of 16.7mm (0.66") and the two Admix samples had an average depth of 15mm (0.6"). According to the LST 1330 standard, less than 20mm (0.8") penetration indicates an impermeable concrete. The Concentrate samples decreased the water permeability by three times and the Admix by four times compared to that of the controls.

"*Evaluation of the Effect of Xypex Admix C-1000 NF to Waterproof Concrete Specimens with a High w/c Ratio"*, Contesta Oy, Helsinki. Finland PERM-224

Concrete samples containing Type 42.5 N cement were cast, including one reference and various samples dosed with Xypex Admix C-1000 NF. The dosage rate of the Admix was varied, although only the 1.5% and 3% dosage rates samples were ultimately evaluated. The normal recommended maximum dosage of Admix C-1000 NF is 1.5%. It also should be noted that the mix design used a high w/c ratio (0.69- 0.71); which is also beyond the recommended range of water in relation to the cement content. All samples were evaluated for permeability by measuring the depth of penetration at 28 days; the reference sample recorded a penetration depth of 150mm, while the sample dosed with the Admix at 1.5% recorded depth of 55mm and the sample dosed at 3% had a 65mm depth of penetration. Clearly, this mix design pushes beyond the normal recommended range for the Admix; nevertheless the results indicate that the Admix at 1.5% reduced the permeability significantly.

EN 12390-8, "*Depth of Water Penetration on Samples Treated with Concentrate Coating", Testing Laboratory No. 1048,* Czech Technical University, Prague, Czech Republic. PERM-227

Three replicate 150mm concrete cubes from four different mix designs (strength classes) were coated with Xypex Concentrate at a thickness of 0.8mm to 1mm. Controls for each of the different mix designs were cast for comparison purposes. All samples were exposed to 0.5MPa (73 psi) of water pressure for 72 hours from the opposite side of the treated surface. Specimens from each set were split transversely from the treated surface at 28 day and 91 day to measure depth of water penetration from the exposed surface. After 28 days, the Xypex coating reduced the depth of water penetration by 90 to 94% compared to the control mixes for the four mix types. At 91 days all Xypex treated sample measured <1mm of water penetration.

DIN 1048 *"Depth of Water Penetration on Samples Treated with Concentrate Coating and Admix C-1000 NF",* Construction and Maintenance Technology Research Center (CONTEC), Sirindhorn International Institute of Technology (SIIT) of Thammasat University, Bangkok, Thailand PERM-228

The objective of this testing was to determine the depth of water penetration of samples with varying mix designs, including: PC specimens (C100); 30% fly ash replacement samples (C70 FA30); Admix C-1000 NF samples (CAA) dosed at1% by cementitious content and specimens coated with Xypex Concentrate (CCM) at a thickness of 1mm. The w/b ratio of the samples was varied (0.5 or 0.6). Concrete samples measuring 150 x 150 x 150mm were cast and demolded after 24 hours. These specimens were separated into 3 sets; set no.1 was for the controls; set no. 2 for concrete coated with Concentrate (-C); and the 3rd set is concrete containing Admix C-1000 NF (-A1) The specimens were removed from their molds at 8 hours after casting, sealed in plastic and cured for 6 and 27 days, then installed in the water permeability apparatus to be tested according to the DIN 1048 methodology. The specimens were exposed to 5-bar / 148 psi water pressure for 3 days. The specimens were then removed and split transversely to measure depth of water penetration from 3 location (i.e. 25mm from each side and at the middle of the specimens). The data points provide an average measurement depth. The specimens were tested at 7 and 28 days of curing. The coated specimens cured for 28 day (0.5 FA30-C & 0.6 FA30-C) showed a significant lesser depth of penetration to that of the controls (i.e. 4.1 mm / 0.16" & 4.6mm (0.18") compared to 9.1mm (0.36") for the controls. For specimens dosed with C-1000 NF, namely 0.5 FA30A1 and 0.6 FA30A1 there was a remarkable reduction in the depth of water penetration from 1.3mm (0.05") and 2.4mm (0.09") compared to the controls.

EN 12390-8 Taywood Modified Throughput Test Procedures "*Test of Water Permeability for Concrete Treated with Xypex Admix C-1000 NF*", Munn, Chang & Kao – Australian Centre for Construction Innovation, University of New South Wales, Sydney, Australia PERM-229

Xypex Admix C-1000 NF was evaluated for a number of properties to determine its effect on concrete durability in aggressive environments. Two different 32MPa (4640 psi) mix designs were utilized (GP / Portland cement only and GB / 20% Fly Ash replacement; the samples included controls and C-1000 NF samples (dosed at 0.8% and 1.2%). The ACCI test apparatus was modified from the Taywood water permeability test apparatus. The specimens were cured in limewater for 90 days before commencing testing. An epoxy was used to seal the sides of the test specimens prior to installing in the apparatus and applying pressure to the top sides. Water pressures of 6 bars and 10 bars (60 and 100 meters of water head) were applied to the samples during the test period. Water leakage through the samples under the pressure was monitored and recorded. The Xypex treated specimens (Mix PC3 – dosed at 1.2% Admix with 330kg of Portland cement) test at 100MPa, showed no evidence of leakage. However, the controls of this same Mix-PC1 were tested at the lesser 60MPa (8,700 psi), showed leakage. The calculated water permeability coefficient for Mix-PC2 was significantly lower ($0.98x10^{-12}$) than the control (Mix-PC1 @ $1.76x10^{-12}$). Since no water transmission was measure for the Type-GB samples, including the controls, the samples were split transversely to measure depth of penetration; the Xypex treated specimens (Mix-FA2) showed no penetration; the control (Mix-FA1) recorded an average of water penetration of 8mm.

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CSN 72 1020, *"Determination of Coefficient of Permeability of Concrete Samples Treated with Xypex Admix C-1000",* Stavebni Geologie – Geotechnika A.S., Prague PERM-230

Xypex Admix C-1000 treated repair mortars, one for hand application, the other for dry-mix shotcrete application, were evaluated for water permeability. Six test samples measuring 150 x 150mm were prepared and cured for 28 days; a control mix was previously cast and tested. Initial permeability testing was conducted according to standard CSN 72 1020; samples were then placed in a water bath for 60 to 70 days and then re-tested to determine the effect of extending the curing regime. The initial test results for the hand applied mortar decreased permeability by 67.6% compared to the control mix; for the dry-mix shotcrete the samples were 43.7% less permeable. When tested at 60 days following submersion in a water bath, the hand application samples recorded a 98.7% decrease in permeability compared to the initial control mix permeability; the dry-mix shotcrete samples submerged in a water bath for 70 days recorded a decrease in permeability of 94.7%.

EN 12390-8 and JUS U.M1.015, *"Study on the effects and efficacy Xypex Admix C-1000 NF Chemical Admixture*", Institute for Materials and Structures, University of Sarajevo, Faculty of Civil Engineering, Sarajevo, Bosnia and Herzegovina. PERM-231

Concrete samples containing Xypex Admix C-1000NF at a dosage rate of 1.2% were tested for water permeability against control samples using two standard procedures. Variables included mixtures with and without superplasticizer and with and without air entraining agent. Design strength for the concrete was 40 MPa using CEM II/B-W 42,5N cement (20-35% high-lime fly ash). One extra mix, containing a higher cement content and Xypex Admix was also cast without a control for comparison. Results of EN 12390-8 water penetration tests showed 3mm of water penetration for Xypex treated samples compared to 52mm of penetration for control samples (superplasticized concrete). In the JUS U.M1.015 procedure the Xypex treated samples had an average penetration of 8 mm compared to 57mm for control on the superplasticized mix. For the non-superplasticized air entrained mixture the results were 10mm and 78mm for Xypex treated and control samples respectively.

NBR 10787/11 – *"Hardened Concrete: Determination of Water Penetration under Pressure",* Holanda Engenharia Ltda., Italiaia, Brasil PERM-232

Concrete cylinders measuring 150mm diameter x 300mm in length were cast utilizing a design mix containing 348kg of cement with a 0.55 w/c ratio. This included controls and 2 separate sets of Admix C-500 NF treated samples, one set dosed at 0.8 % of the cement content, the other set at 1.0%. The samples were cured by utilizing a moist / dry cycling rotating every 5 days. At 21 days following casting 3 samples from each group of specimens were subjected to a pressure regime of 48 hours at 0.1MPa, then 24 hours at 0.3MPa and then another 24 hours at 0.7MPa. At 28 days, 3 control samples and 3 samples from each of the 2 different Admix dosed sets were split transversely to measure depth of penetration. The 28 day results recorded the average depth of penetration for the controls at 29.03mm; the 0.8% dosed Admix samples at 23.3mm and the 1.0% dosed samples at 18.21mm. The remaining samples were exposed to the same pressure regime with measurements taken at 56 days for the Admix samples and 67 days for the controls. The 56 day results recorded the average depth of penetration for the 0.8% Admix samples at 14.9mm and the 1.0% dosed samples at 13.05mm; the controls tested at 67 days results were measured at 29.67mm. In evaluating these results using the Valenta permeability measurement, we have calculated the K values as follows: the controls at 28 days: K = $1.0E^{-12}$ and at 67 days: K = $1.0E^{-12}$; the C-500 NF samples dosed at 0.8%: K= 6.4E-13 (i.e. this represent a 36% reduction compared to controls); 56 days: K=$2.6E^{-13}$ (i.e. a 74% reduction compared to controls); Admix C-500 NF samples dosed at 1.0% at 28 days: K= $3.9E^{-13}$ (i.e. a 61% reduction compared to controls); and at 56 days: K= $2.0E^{-13}$ (which represents a 80% reduction compared to control).

STN EN 12390-8 ***"Testing of Hardened Concrete; Depth of Water Penetration under Pressure",*** **Technical and Testing Construction Institute, Bratislava, Slovakia**
PERM-233

Cubes measuring 150 mm x 150 mm were cast utilizing class C25/30 concrete and three replicate samples each were dosed with Admix C-1000 @ 2%; Admix C-1000 NF at 1%; controls were also produced. Water pressure of 0.5 MPa was applied to all specimens for 72 hours. Samples were then split transversely from the side of the cubes exposed to the water pressure in order to measure depth of water penetration. Admix C-1000 samples recorded an average water penetration depth of 10.3mm; the C-1000 NF samples averaged 25mm; while average depth of penetration or the controls was 113mm. In calculation the Valenta Permeability Coefficient, the Admix C-1000 K = $4.09E^{-13}$ m/s; the Admix C-1000 NF K= $2.41E^{-12}$ m/s; and the control K= $4.926E^{-11}$ m/s. This represents a water permeability reduction for the Admix C-1000 and C-1000 NF samples from 20 to 120 times when compared to the control concrete.

EN 12390-8 ***"Testing Hardened Concrete; Depth of Penetration of Water under Pressure",*** **Faculty of Civil Engineering, Czech Technical University of Prague, Czech Republic** **PERM-236**

Regular testing is carried out on concrete specimens collected from project sites to confirm the effectiveness of Xypex Admix C-1000 NF to provide watertight concrete. Specimens are exposed to pressurized water at 0.5MPa for 3 days as per EN 12390-8 and then evaluated for depth of penetration at various ages to determine the extent of crystalline growth and thus enhanced protection over time. One example of this is specimens using a C 30/37-90D XA1 mix design containing Admix C-1000 NF, retrieved from Skanska Transbeton's Riverview project in Prague; testing results recorded a 71% decrease in depth of water penetration at 150 days compared to the 90 day results. A second example relates to specimens utilizing a C 25/30-90D XA1 mix design with Admix C-1000 NF obtained from Cemex's hospital project in Uherske Hradiste, Czech Republic; testing recorded a 79% decrease in the depth of water penetration at 150 days compared to results obtained at 90 days. The third example is concrete specimens with a C 25/30-90D XA1 mix design dosed with Admix C-1000 NF, supplied by TBG Metrostav of the Heidelberg Group for the Medox II project in Prague; testing results recorded a decrease of 83% in the depth of water penetration at 180 days compared to the measurements at 90 days.

EN 12390-8 ***"Testing Hardened Concrete; Depth of Penetration of Water under Pressure",*** **Hans Jacobs GmbH, Baustoffprűfung, Hamburg, Germany** **PERM-237**

Testing is regularly performed to ensure compliance with the requirements of the DIBt. Concrete containing 300 kg of cement with and without Admix C-1000 NF are evaluated at 28 days age. In one such test, the Xypex Admix treated specimens recorded an average depth of penetration of 27.5 mm compared to the reference specimens of 88 mm.

***EN 12390-8 "Testing Hardened Concrete. Depth of Penetration Exposed to Water under Pressure",* AS TEEDE TEHNOKESKUSE Laboratoorium, Tallinn, Estonia PERM-238**

C 20/30 concrete 150mm concrete cubes with a coating of Xypex Concentrate applied at 1kg/m^2 to a concrete with a 0.785 w/c ratio and subsequently a 0.55 w/c ratio. Other samples were dosed with Xypex Admix C-1000 at a 2% dosage rate in a concrete with a w/c ratio of 0.55, Controls were cast along with the treated ones. All specimens were subsequently tested for resistance to water at a pressure of .5MPa for 10 days. The Concentrate samples recorded an average depth of penetration of 19 mm for the samples utilizing a w/c ratio of 0.785 and 18mm for the ones with a w/c ratio of 0.55; the reference samples in comparison average 31mm of penetration. Xypex Admix C-1000 samples recorded an average depth of penetration of 14mm compared to 18mm of the reference samples. It should be noted that the testing period was only 10 days and in reality for the crystalline growth to fully develop to show the full extent of the Xypex's ability requires a minimum 28 days following application of the coating or casting of the concrete with the Admix.

***EN 12390-8 "Testing Hardened Concrete; Depth of Penetration Exposed to Water under Pressure",* TSUS Technical and Testing Building Institute, Bratislava, Slovak Republic. PERM-240**

Three sets of samples made from C 25/30 concrete were tested for impermeability. One set contained Xypex Admix C-1000; a second set contained Admix C-1000 NF the third set was untreated for comparative purposes. Results of the testing recorded an average 85% reduction in water penetration in the Admix samples compared to the untreated concrete samples.

"Measurement of Mass Concrete Humidity"; Czech Technical University, (CVUT) Faculty of Civil Engineering, Prague, Czech Republic. PERM-305

This experiment was required to convince a building owner of the efficacy of the Xypex system to waterproof the below ground foundations of an apartment structure that had significant leaking despite having a HDPE foil / Bentonite system / injection tube in place and having a subsequent failure with an injection system to stop the serious leaking. The testing involved creating concrete test specimens of 300 x 300 x 220mm; these dimensions replicate the concrete of this basement wall. After 28 days, a coat of Concentrate was applied to a set of test specimens as per Xypex specifications; several sets of specimens were left untreated as controls (one for wet exposure and another for dry exposure). A plastic container was then tightly sealed onto the surface of the first two sets of test specimens; (in the case of the Xypex samples, this was on the opposite surface to which the coating was applied). The container was filled with water and a constant level was maintained. On the opposite side of the concrete specimen 6 mm holes were drill to a depth of 30-40mm from the exposed surface where the water containers were situated. Brush probes of the electric resistance hygrometer used to measure the mass humidity were subsequently inserted. Measurement of humidity at intervals of 28, 45, 90, 125 and 132 days was recorded. At the conclusion of this testing, each sample was split perpendicularly to the moisture loading surface and small samples of concrete were extracted adjacent to where the probes had been measuring humidity to calibrate the results by gravimetric measurement. The deviation in measuring was less than 5%. The results indicated that there was a significant decrease in humidity over the testing period between the Xypex treated specimens at 4.6 % humidity and the untreated set at 7.9%. Interestingly, the third set that had had no exposure to water was measured also and had a humidity reading of 4.4% essentially equivalent to the Xypex specimens.

CHEMICAL PERMEABILITY RESISTANCE

"*Test Procedures Evaluating Fluid Tightness and Measurement of Penetration under Pressure of Sulfuric Acid and Sulfide",* Technical Testing Institute of Civil Engineering, Bratislava, Slovak Republic

REST-200

Eighteen concrete samples measuring 150 x 150 x 150mm were prepared to the standard Class B 20 (STN 73 2400). Six samples were prepared with a one coat application of Xypex Concentrate; another six had a second coat of Concentrate applied. The twelve treated samples and six reference samples were similarly cured in a moist curing room. A similar number of each of the above samples was subjected to a solution of either Sulfuric Acid or Sulfide using an apparatus that exerted 1.20kPa of pressure for a 7 day period. Special measures were taken to avoid evaporation or volatilization of the solutions. Each sample was then split transversely to expose the depth of penetration of the solution. In the Sulfuric Acid test, the three samples with the single Xypex Concentrate coating and the three samples with a two-coat application showed an average 1.2mm for the depth of penetration. The three non-treated samples showed an average penetration of 48 mm. In the test using the Sulfide solution, all six samples with the Xypex Concentrate coating(s) had no penetration. The three non-treated samples showed an average penetration of 1.7mm.

***"Test Procedures Evaluating Fluid Tightness and Measurement of Penetration under Pressure of Acetone",* Technical Testing Institute of Civil Engineering, Bratislava, Slovak Republic REST-201**

Eighteen concrete cubes measuring 150 x 150 x 150mm were prepared to the standard Class B 20 (STN 73 2400). Nine samples were prepared with a single coat application of Xypex Concentrate and then cured. Nine reference samples were similarly cured. All samples were then subjected to a solution of Acetone using an apparatus that exerted 1.70 kPa of pressure for a 7 day period. Special measures were taken to avoid evaporation or volatilization of the solutions. At intervals of 24 hours, 3 days and 7 days of exposure, three treated and three untreated samples were split transversely to expose the depth of penetration of the solution. All nine samples with the Xypex Concentrate coating showed no penetration. The three non-treated samples broken at 24 hours showed an average penetration of 21.7mm. The three non-treated samples broken at 3 days showed an average penetration of 36.7mm. The three non-treated samples broken at 7 days showed an average penetration of 48.3mm.

"Test Procedures Evaluating Fluid Tightness and Measurement of Penetration under Pressure of Turpentine", Technical Testing Institute of Civil Engineering, Bratislava, Slovak Republic REST-202

Twenty-one concrete cubes measuring 150 x 150 x 150mm were prepared to the standard Class B 20 (STN 73 2400). Nine samples were treated with a single coat application of Xypex Concentrate. Nine other samples were prepared with a coat application of Xypex Concentrate and a second coat of Xypex Modified. All Xypex samples were cured as specified. Three similar untreated concrete samples were prepared and cured for reference purposes. All samples were then subjected to a solution of Acetone using an apparatus that exerted 5.95kPa of pressure. Special measures were taken to avoid evaporation or volatilization of the solutions. At intervals of 7 days, 14 days and 28 days of exposure, three samples treated with a single Xypex Concentrate and three samples with a two coat application of Xypex Concentrate and Xypex Modified were split press transversely to expose the depth of penetration of the solution. The samples with the single Concentrate coating recorded the following average results: 7 days - 2 mm, 14 days - 5.8mm and 28 days 10.5mm. The samples with a two coat application of Concentrate and Modified recorded the following average results: 7 days - 3.5mm, 14 days - 5.7mm and 28 days 8.3mm. The three non-treated samples were all broken at 28 days and showed an average penetration of 75mm.

PETROLEUM PRODUCTS PERMEABILITY TESTING

Test Procedure No. 28, "*Impermeability and Resistance to Diesel Oil*", Klokner Institute, Czech University, Prague, Czech Republic PETR-100

Xypex treated samples were exposed to various liquids, including silage juices, diesel oil, gasoline and transformer oil to a pressure of 14kPa. Cylinders with a diameter of 100mm and a length of 50mm were treated on one end with a coat of Concentrate and 9 samples with an additional coat of Modified. 12 untreated cylinders were not coated for control purposes. For moist curing the untreated ends of the Concentrate and Modified cylinders (as well as the control samples) were partially submerged in 10 mm of water; this was followed by 2 days of air curing. A funnel was affixed to the treated ends and water was placed in all specimens for 3 days under 1.4kPa of pressure. The water was then discharged and representative samples were exposed to: liquid silage, diesel oil, gasoline or transformer oil for 28 days of exposure. A constant 14kPa of pressure (i.e. 1.4m of head pressure) was maintained on each specimen. All samples were then split open transversely to expose the depth of penetration. With each liquid, the Xypex treated samples significantly reduced the depth of penetration compared to that of the control samples.

Test Procedures for Impermeability and Resistance to Crude Oil", Institute of Civil Engineering, Technology and Testing, Bratislava, Slovak Republic PETR-101

Xypex-treated and untreated concrete samples were tested to determine resistance and impermeability to crude oil. A PVC tube measuring 1500 mm in height and 100mm in diameter was attached to the surface of each specimen. The tubes were filled up to 1400mm in height of crude oil and sealed at the top to prevent evaporation. Samples included: untreated concrete specimens, samples with 1 coat of Concentrate, samples with 1 coat of Modified, samples with 2 coats of Concentrate and samples with 2 coats of Modified. Both treated and untreated samples were subjected to contact with crude oil up to 14kPa (1.4m of water column) for 28 days – the level was maintained throughout the duration of the test. Samples were split transversely to expose the depth of the liquids' penetration. The average depth of penetration on the Xypex-treated samples single coat samples averaged 3mm, the two-coat application had no penetration while the controls average 105mm of penetration.

CSN1209 & 1321 "*Test Procedures for Impermeability and Resistance to Various Fluids Impermeability and Resistance to Pressurized Water",* Institute of Civil Engineering, Technology and Testing, Bratislava, Slovak Republic PETR-102

The basis of this test regime was to determine the ability of Xypex treated concrete in comparison to untreated concrete to make concrete impermeable to various fluids, including: diesel oil, transformer oil, gasoline, silage juices and pressurized water. Samples included: un-treated concrete specimens, samples with 1 coat of Concentrate, samples with 1 coat of Modified, samples 2 coats of Concentrate and samples with 1 coat of Concentrate and a second coat of Modified. Two separate test procedures were utilized. The first test procedure exposed both treated and untreated concrete specimens to contact with the above solutions. A PVC tube measuring 1500mm in height 100mm in diameter was attached to the surface of each specimen and the tubes were filled with each of the solutions to a height of 1400mm (i.e. 1.4MPa / 1.4m of head pressure) and was maintained for 28 days. The samples were then split transversely to visually examine and measure the depth of penetration of each solution. In each case, it was noted that the Xypex treated samples reduced the depth of penetration of the various fluids. In the gasoline permeability test the Xypex coating(s) measured 0 mm, while the reference samples averaged 53mm at 28 days. In the diesel permeability test, the Xypex 2 coat application measure a depth of penetrate of 26 m, as compare to 140mm of the reference samples at 28 days. In measuring the depth of penetration of transformer oil, Xypex 2-coat system measured 1.5mm compared to 58mm at 28 days. Regarding the depth of penetration of silage juices, the Xypex 2 coat samples averaged 6mm, while the reference samples averaged 73mm.

CSN 73 1321, *"Test for Permeability of Various Liquids through Concrete"*, Klokner Institute, Czech University, Prague, Czech Republic PETR-104

Two standard concrete mix designs utilized in Central Europe (i.e. B25 and B45) were dosed with the C-1000 Admix at 8kg/m^3. Three 200 mm cubes and three 150mm cubes were created for each of the different mixes including controls and treated specimens. All the specimens were curing in water baths for 6 days followed by air curing for 28 days. A compressive strength test was performed at 28 days on the 150mm cubes to determine a mean value of the specimens in relation to that established for the particular mix design. One of the 200mm cubes from each mix design were then subjected to water-tightness testing (CSN EN 12390-8) for 4 days at 50m of head pressure. Subsequently, each of the remaining 200mm cubes had a measuring tube affixed to its surface and filled with either unleaded gasoline or diesel fuel. The level of the media was monitored and maintained for 48 hours with a constant 0.15m head of pressure. The samples were then split transversely to expose the depth of penetration of the gasoline and diesel into the samples. Measurements were taken from five positions on the fractured plane. Despite the relatively short exposure period (i.e. 48 hours) the control samples exhibited very poor performance results. With regards to the depth of penetration when exposed to water, the B25 control was 26.8mm, whereas the Admix sample of the same mix was 13.1mm. When exposed to the unleaded gasoline, the B25 control measured an average depth of penetration of 82.1mm compare with 8.2 of the Admix sample. The better quality mix (i.e. B45) recorded a depth of 56.7mm for the control as compared with 7.9mm for the Admix treated sample. The two untreated mix when exposed to the diesel fuel average a depth of penetrate of 20.4mm whereas the Admix samples average depth measured 3.5mm. This test provides convincing evidence of the benefit of utilizing the Admix in either mix design to substantially improve the resistance to gasoline and diesel fuel.

TSUS Test Procedure No. 1/1994 "*Determination of the Resistance and Impermeability to various Oil Products and Silage";* TSUS Technical and Testing Building Institute, Bratislava, Slovak Republic. PETR-105

Concrete containing Xypex Admix was tested for penetration resistance to various liquids including crude oil, diesel, transformer oil and silage juice. Concrete samples of Class C25/30 (25-30MPa) were prepared with 2% Xypex Admix C-1000 and 1% Xypex Admix C-1000 NF by mass of cement. Control samples without Xypex were also prepared. Testing was completed by subjecting 150mm cube specimens to a pressurized liquid for 1, 2 and 3 days (varying on the liquid) using a 500mm standpipe attached to the samples. Following the pressure application, samples were spit and the maximum depth of liquid penetration was measured for each of the three replicates for each mix. For exposure to transformer oil, Xypex Admix C-1000 reduced penetration depth by 59% and Admix C-1000 NF reduced penetration by 48% compared to the control. For exposure to diesel, the reduction was 36% and 27% for Admix C-1000 and C-1000 NF respectively. For crude oil exposure, the reduction for Xypex Admix C-1000 was 45%; C-1000 NF was not tested. For exposure to silage juice, the reduction was 68% and 55% for Admix C-1000 and C-1000 NF respectively.

CSN 73 1321, *"Test for Permeability of Gasoline and Transformer Oil under Pressure through Concrete",* AS TEEDE TEHNOKESKUSE Laboratoorium, Tallinn, Estonia PETR-106

C 20/30 concrete 150mm concrete cubes with a coating of Xypex Concentrate applied at 1 kg/m^2 to a concrete with a 0.785 w/c ratio and others subsequently with a 0.55 w/c ratio. Another sample set was dosed with Xypex Admix C-1000 at a 2% dosage rate in a concrete with a w/c ratio of 0.55, Controls were cast along with the treated ones. All specimens were subsequently tested for resistance to both gasoline and transformer oil under a pressure of 0.15m utilizing a standpipe apparatus. The Concentrate samples recorded an average depth of penetration for exposure to gasoline of 3mm for the samples utilizing a w/c ratio of 0.785 compared to 10mm for the controls and 5mm for the ones with a w/c ratio of 0.55 compared to the controls at 16mm of penetration. Concentrate samples recorded an average depth of penetration for exposure to transformer oil of 7mm for the samples utilizing a w/c ratio of 0.785 compared to 11mm for the controls and 10mm for the ones with a w/c ratio of 0.55 compared to the controls at 15mm of penetration. Xypex Admix C-1000 samples exposed to gasoline recorded an average depth of penetration of 2mm compared to 12mm of the controls at 2 days and at 7 days recorded an average depth of penetration of 5mm compared to 16mm of the controls. Xypex Admix C-1000 samples exposed to transformer oil recorded an average depth of penetration of 7mm compared to 11mm of the controls at 2 days and at 7 days recorded an average depth of penetration of 10mm compared to 15mm of the controls

CHEMICAL RESISTANCE

ASTM C 267-77 *"Chemical Resistance of Mortars"*, Pacific Testing Labs, Seattle, USA CHEM-100

Xypex-treated cylinders and untreated cylinders were exposed to hydrochloric acid, caustic soda, toluene, mineral oil, ethylene glycol, pool chlorine and brake fluid and other chemicals. Results indicated that chemical exposure did not have any detrimental effects on the Xypex coating. Following chemical exposure, the Xypex treated specimens had measured an average 17% higher compressive strength over the untreated control samples.

"*Evaluation of Resistance to Acid Attack*", Japan Atomic Energy Research Institute, Tokyo, Japan **CHEM-101**

Xypex treated samples and untreated samples were subjected to a 5% H_2SO_4 solution for 100 days. A measurement of the corrosion ratio (i.e. ratio of final to initial mass) for the treated sample was 11.7%, while the untreated sample was 21.0%.

"*Resistance to Acid Attack*", IWATE University Technical Report, Morioka, Japan **CHEM-102**

Xypex Concentrate treated mortar and untreated mortars were measured for acid resistance after exposure to a 5% H_2SO_4 solution for 100 days. Xypex suppressed concrete erosion to 1/8 of the reference samples.

***"Sulphate Resistance Test",* Taywood Engineering Ltd., Perth, Australia** **CHEM-105**

Xypex Admix-treated concrete samples were immersed in an ammonium-sulphate solution and tested for resistance in a harsh environment. The performance of the Xypex-Crystalline-Technology was compared with five other concretes, including one containing a sulphate-resistant cement and one containing silica fume. Each of the test samples was cured for seven days and then placed in an ammonium-sulphate solution (132g/l) for 180 days. The rate of deterioration was determined by measuring weight loss and length change (bulk expansion) on a weekly basis. The Xypex crystalline technology substantially improved concrete performance as compared to the reference concrete(s) and in particular provided the highest level of protection as measured by lowest relative length gain.

***"Evaluation of Chloride Ion Penetration into Concrete",* Mahaffey Associates Pty. Ltd., Rydalmere, Australia** **CHEM-107**

Five concrete 150mm cylinders containing the Xypex Admix were cast along with similar cylinders with no Admix and other cylinders with a pore blocking additive. All samples were exposed to a varied regime of exposure to a salt water bath. Samples were also tested for compressive strength, flexural strength and drying shrinkage. Samples from each of the cylinders were cycled in and out of salt water every 24 hours for 28 days, 90 days and 180 days immediately after casting. Other samples were water cured for 7 days then cycled in and out of salt water every 24 hours for 83 days. Other samples were water cured for 56 days then cycled in and out of salt water every 24 hours for 28 days (i.e. most common form of diffusion testing). Following immersion, each cylinder sample's face was ground down to remove increments of 2 mm depth of concrete dust. The dust samples were then tested for chloride ion content. Results of this chloride ion testing regime clearly indicate that the Xypex treated samples reduce the amount of chloride ion penetration significantly especially if concrete is allowed to cure for 7 days prior to immersion. Based on this regime the amount of chloride diffusion (m^2/s x 10-12) was 11.1 for the untreated concrete sample, 16.4 for the concrete containing the pore blocker and 8.1 for the Xypex Admix sample.

***"Chloride Ion Penetration & Chloride Diffusion Analysis",* Building Research Centre (BRC), University of New South Wales, Sydney, Australia**
CHEM-108

Precast concrete slabs containing Xypex Admix were exposed to a severe marine environment for four years, then were evaluated and tested for chloride ion penetration. A slab that had been manufactured at the same time, but had not been installed and therefore not exposed to the marine environment was used for comparison purposes. Visual observation indicated that the concrete pre-cast planks showed no signs of deterioration as a result of exposure to this harsh marine environment. Concrete powder samples were taken from each slab at four depths (5-15mm, 15-25mm, 25-35mm & 35-45mm). The powder samples were analyzed for chloride ion contents. Test results of the samples containing the Xypex Admix, showed that the chloride content was relatively low and drops rapidly with an increase in the slab depth. A Half-Cell Potential Survey was also performed and a contour map of the deck slab was undertaken to plot any pattern of surface corrosion on the slabs exposed to the marine environment. The results indicated a few minor spots of active corrosion reactions.

AS2350.14, *"Length Change in Sulphate Solution of 32 MPa Concrete Containing Admix C-1000NF / C-2000NF",* Australia Centre for Construction Innovation, University of New South Wales, Sydney, Australia
CHEM-109

Potential expansion of concrete in sulphate environments was assessed in accordance with AS2350.14 by immersing mortar samples in a 5% sodium sulphate solution over 16 weeks. Concrete samples containing Xypex Admix C-1000NF & C-2000NF at different dosage rates (0.8% and 1.2%) were tested against untreated control samples for sulphate resistance. Samples had a design strength of 32MPa and varied from Type-GP concrete to Type-GB (includes 20% fly ash).The test data showed the use of Xypex Admix demonstrated significant improvements in sulphate resistance (low expansion). The best results re lower expansion in the sulphate solution were achieved with the higher dose rate of 1.2% of Xypex Admix.

AS2350.14, "*Length Change in Sulphate Solution of 40 MPa Concrete Containing Admix C-1000NF*", Australia Centre for Construction Innovation, University of New South Wales, Sydney, Australia CHEM-110

Potential expansion of concrete in sulphate environments was assessed in accordance with AS2350.14 by immersing mortar samples in a 5% sodium sulphate solution over 16 weeks. All nine commercial concretes had design strength of 40 MPa (specified for marine applications) and included 3 different Type-GB cements, a 25% fly ash blend and two slags (38% and 60%) blends. Concrete samples containing Xypex Admix C-1000NF were tested against untreated control samples for sulphate resistance. The test data showed the use of Xypex Admix demonstrated significant improvements in sulphate resistance (low expansion). For the 25% fly ash mix, the 0.8% and 1.2% Admix C-1000 reduced expansion by 40% and 54% respectively. The Type-GB 38% slag blend treated with the Admix reduced expansion up to 16%. The Type-GB 60% slag concrete blend treated with the Admix reduced expansion up to 46%.

AS2350.14, "*Length Change in Sulphate Solution of 40 MPa Concrete Containing Admix C-500 NF / C-5000*", Australia Centre for Construction Innovation, University of New South Wales, Sydney, Australia CHEM-111

Potential expansion of concrete in sulphate environments was assessed in accordance with AS2350.14 by immersing mortar samples in a 5% sodium sulphate solution over 16 weeks. The four commercial concretes had design strength of 40 MPa (specified for marine applications) and included Type-GB cement with 25% fly ash blend and Type GB cement with 38% slag blend. Concrete samples containing 0.5% Xypex Admix C-5000 (equivalent to 0.8% C-500) was tested against untreated control samples for sulphate resistance. The test data showed the use of Xypex Admix demonstrated significant improvements in sulphate resistance (low expansion). For the 25% fly ash mix there was 26% reduced expansion and for the Type-GB 38% slag blend treated with the Admix reduced expansion up to 16%.

NT BUILD 443, ACCI Modified Test, *"Chloride Diffusion by NordTest with 16.5% NaCl solution of 32 MPa Concrete Containing Admix C-1000NF / C-2000NF"*, Australia Centre for Construction Innovation, University of New South Wales, Sydney, Australia CHEM-112

Nordtest NT BUILD 443 is a standard accelerated method for evaluation of the chloride diffusion coefficient of concrete. Three Type-GP cements, two Type GB fly ash blended cements and two Type GB slag concretes were evaluated. Controls and Admix modified concretes were immersed in a 16.5% NaCl solution for 42 days. The chloride diffusion coefficients were calculated according to Fick's Second Law based on the chloride content profiling. Significant reductions in the chloride diffusion coefficients were found with all the Xypex Admix modified concretes. The Type-GP treated samples with the Admix had 30% lower chloride ion diffusion coefficients than the controls. The fly ash and slag samples containing the Admix had 50% and 67% lower diffusion coefficients respectively. Chloride penetration depth as indicated by silver nitrate was also examined on these samples following splitting them transversely. Type-GP samples illustrated C-1000 NF treated specimens reduced the depth of penetration of chlorides up to 32%. Fly ash treated sample illustrate the Admix reduced penetration by 38%. There were slightly less penetration in the slag samples that contained the Admix over the controls.

NT BUILD 443, ACCI Modified Test, "*Chloride Diffusion by NordTest with 16.5% NaCl solution of 40 MPa Concrete Containing Admix C-1000NF*", Australia Centre for Construction Innovation, University of New South Wales, Sydney, Australia CHEM-113

Nordtest NT BUILD 443 is a standard accelerated method for evaluation of the chloride diffusion coefficient of concrete. Xypex Admix modified concretes were immersed in a 16.5% sodium chloride solution for 35 days. The chloride diffusion coefficients were calculated according to Fick's Second Law based on the chloride content profile in the concrete samples after immersion. Significant reductions in the chloride diffusion coefficients were found with all the Xypex Admix treated samples. Type-GB concrete containing fly ash treated with the Admix had 25% lower chloride ion diffusion coefficients than the controls. The 38% slag samples containing the Admix averaged 71% lower diffusion coefficients than the control. The 60% slag concrete treated with the Admix averaged 47.5% lower diffusion coefficients than the controls.

"*Evaluation of Effects of Exposure to Salt Solution*", Building Materials Testing Center, Tokyo, Japan CHEM-116

Concrete specimens were examined for effects of exposure to a chloride solution. Three concrete mixes with design strengths of 230, 325 & 448 kg/cm^2 (i.e. 22.6MPa, 31.9MPa & 43.9MPa) were tested. Control samples were compared to samples coated with Xypex Concentrate. All specimens contained an embedded reinforcing steel bar and were exposed to a salt solution shower for 12 hours at 50^{o}C and then exposed to 60^{o}C forced air for 12 hour periods over 270 days. The percentage corrosion rate of the Xypex treated samples was reduced by 2/3 compared to the reference sample. The chloride content of the Xypex treated concrete was also 2/3 of the control specimens.

"*Evaluation of Xypex on Limiting the Effects of AAR on Concrete*", CSIRO, A Division of Building, Construction and Engineering, Victoria, Australia CHEM-117

The influence of Xypex Concentrate coating on AAR susceptible concrete was studied. Concrete prisms with AAR aggregates were cast with low alkali and high (1.38%) alkali contents. All test specimens were kept in an aggressive environment at 40^{o}C and 100% R.H. and monitored for over 100 weeks. Coating the concrete with AAR aggregates and low alkali content did not aggravate or result in expansion. Coating the concrete with AAR and high alkali content, which has cracked due to AAR did not aggravate the AAR and may reduce the extent of expansion.

CSIRO Modified ASTM C-1202 Method *"Rapid Chloride Ion Penetration of 32 MPa Concrete Containing Admix C-1000NF / C-2000NF"*, Australia Centre for Construction Innovation, University of New South Wales, Sydney, Australia CHEM-118

Concrete samples using Type-GP cement and Type-GB containing 20 % and 40% fly ash were evaluated for the effect that the Xypex Admix had on reducing the amount of electrical charge through the specimens. Results indicated that the control mix of the Type-GP cement had the highest measurement at 4249 coulombs, while the three Xypex samples recorded an average of 3776 coulombs. Fly ash control illustrated considerable reduction in coulombs compared to the Type-GP cement with a reading of 1278 coulombs. The fly ash samples containing the Admix showed further reductions, in particular the samples dosed at 1.2% Admix C-1000 NF and Admix C-2000 NF had the highest reduction, from 758 coulombs (41%) and 733 (43%) coulombs respectively.

CSIRO Modified ASTM C-1202 Method *"Rapid Chloride Ion Penetration of 40 MPa Concrete Containing Admix C-1000NF",* Australia Centre for Construction Innovation, University of New South Wales, Sydney, Australia CHEM-119

Nine different concrete mixes were evaluated to determine the effect of adding 0.8% and 1.2% C-1000 NF by cementitious content on reducing the amount of electrical charge through the specimens. Within the Type-GB 25% fly ash mix, the control recorded the highest charge at 5182 coulombs, while the Admix samples (0.8 % and 1.2% dosage rates) had significant reductions (i.e. 76% and 90% respectively). Of the Type-GB 38% slag cement concretes, the control recorded an electrical charge of 1143 coulombs, while Admix samples (0.8 % and 1.2% dosage rates) had further reductions (i.e. 338 and 308 coulombs respectively). The Type-GB 60% slag samples recorded the following results: control - 795 coulombs, the 0.8% Admix - 419 coulombs and the 1.2% Admix – 306 coulombs. With the two Xypex samples of the 60% slag mix, there was a 47% and 62% lower charge as compared to the control.

ACCI Method *"Static Chloride Penetration Test of 32 MPa Concrete Containing Admix C-1000NF / C-2000NF"*, Australia Centre for Construction Innovation, University of New South Wales, Sydney, Australia CHEM-121

Concrete samples using Type-GP cement and Type-GB containing 20% and 40% fly ash were evaluated for the effect that the Xypex Admix had on reducing the depth of penetration of chlorides in sample that are immersed in a 3% sodium chloride solution for 90 days. Following immersions, the 100 x 100 x 200 mm samples were split transversely and sprayed with a silver nitrate indicator to identify the depth of penetration of the chlorides. Results indicated that all Type-GP cement samples containing the Admix recorded less penetration than the control (in the range of 9% less). Types GB fly ash and slag samples generally had better results that the Type-GP cement samples. The two C-1000 NF modified samples recorded a reduction in depth by 21% and 34%, while the C-2000 NF sample reduced penetration depth by 23%. The Xypex treated slag samples recorded a 16% lower depth of chloride penetration than the controls. It was also noted in this test that samples containing a superplasticizer tended to have higher depths of penetration.

ACCI Method *"Cyclic Chloride Penetration Test of 32 MPa Concrete Containing Admix C-1000NF / C-2000NF"*, Australia Centre for Construction Innovation, University of New South Wales, Sydney, Australia
CHEM-122

Concrete samples using Type-GP cement, Type-GB containing 20 % and 40% fly ash, Type-GB with 38% and 60% slag replacement, and a ternary blend with both fly ash (20%) and slag (30%) were used in this study. Several sample mixes also contained a superplasticizer. The study also examined the effect of hand-finished surfaces as opposed to the moulded surface. Samples were exposed to cycles of 12 hrs in a 15% sodium chloride solution followed by 12 hrs drying under heat lamps for 14, 28 and 56 day periods in order to accelerate chloride penetration. The Type-GP samples had the most penetration, although the Xypex treated samples performed better than the controls. The fly ash and slag sample recorded much lower chloride penetration than GP concretes, and samples containing the Admix C-1000 NF further reduced penetration by between 15% - 20% compared to the fly ash control. The slag concrete sample containing the Admix recorded a 9% reduction compared to the slag control. Extending the test to 56 day continued to show the benefit of using a fly ash or slag mix along with the Xypex Admix due to the reduction in porosity and the effects of crystallization on making the concrete less permeable.

ACCI Method *"Cyclic Chloride Penetration of 40 MPa Concrete Containing Admix C-1000NF",* Australia Centre for Construction Innovation, University of New South Wales, Sydney, Australia CHEM-123

Nine different concrete mixes were evaluated. Samples were exposed to cycles of 12 hrs. in a 15% sodium chloride solution followed by 12 hrs. drying under heat lamps for 14, 28 and 56 day periods in order to accelerate chloride penetration. The mixes involved concretes dosed with 0.8% and 1.2% Admix C-1000NF added to Type-GB concrete with 25% fly ash, Type-GB with 38% slag and Type-GB with 60% slag. Results of exposure indicated that the best results were in samples containing the 38% and 60% slag mixes, which is considered "low". The Xypex treated samples (especially at the 1.2% dosage rate) further reduced the chloride penetration (up to 20% less than the controls).

ACCI Method *"Chloride Diffusion Test of 40 MPa Concrete Containing Admix C-1000 NF in 3% NaCl Solution"*, Australia Centre for Construction Innovation, University of New South Wales, Sydney, Australia
CHEM-125

Various concrete mixes were evaluated to determine the effect of exposure to a 3% NaCl solution over a 35 day, 105 day and 365 day immersion. The mixes involved 9 different commercial concretes dosed with 0.8% and 1.2% Admix C-1000 NF. The various mixes included 3 different Type-GB mixes with 25% fly ash 38% slag and 60% slag. Significant reduction was recorded in terms of the chloride diffusion coefficient in all Xypex modified samples as compared to the controls. The 35 day results indicate up to a 62% reduction, while the 105 day results recorded up to a 71% reduction in the chloride diffusion coefficient. It was also clear that the 1.2% dosage rate provided more reduction and therefore increased protection. The 365 day results have yet to be reported.

.**ASTM C 267-77 *"Chemical Resistance of Megamix II"*, McGrath Engineering Ltd., Vancouver, Canada** **CHEM-130**

Xypex Megamix II was evaluated against a control mortar for resistance to sulphuric acid solution with pH of 3.0. The Megamix II samples were mixed as per the normal specifications. All samples were kept in a moist curing environment for 28 days prior to testing. All samples were then subjected to a pH = 3.0 H_2SO_4 in tap water for up to 84 days. Solution was changed twice weekly or after each reading to maintain the pH level at 3.0. In measuring the effects, readings were taken at intervals of 1, 7, 14, 28, 56 & 84 days and were evaluated for compressive strength, mass loss and appearance. At 84 days exposure, the Megamix II samples recorded very minor and probably insignificant changes in compressive strength and in mass loss (i.e. -0.22%).

CSN 73 1326 *"Measuring Loss of Surface due to Sulphate Attack of Concrete Treated with Admix C-1000 and Admix C-1000 NF", Betonconsult, Building Materials Testing Laboratory, Prague, Czech Republic.*
CHEM-132

Concrete specimens containing Admix C-1000 at 1 and 2% dosage and Admix C-1000 NF at 0.5% and 1% dosage were cast along with non-treated concrete specimens. All specimens were exposed to a highly concentrated sulfate solution (i.e. 36,000mg/ℓ) for 4 months. All samples were weighed to determine mass loss during exposure; the Admix treated samples in the various dosages showed a mass loss between 5 and 50 g/m^2, while the non-treated specimens measured an average 4,860 g/m^2 mass loss. The samples were also examined for "surface deterioration", which is a clear indication of sulfate attack. All of the Admix specimens showed no visual surface deterioration; the non-treated concrete showed major deterioration. Based on this testing, there is clear evidence of the effectiveness of the Xypex chemistry to provide exceptional resistance to concrete exposed to high concentration of sulfates.

***"Durability of Concrete Modified by Crystalline Coating and Admix Products – Chloride Penetration Resistance with ",* Construction and Maintenance Technology Research Center (CONTEC), Sirindhorn International Institute of Technology (SIIT), Thammasat University, Bangkok, Thailand. CHEM-133**

The testing of hardened cement paste samples was part of an extensive program to determine the benefit of using the Xypex treatment both as a coating and as an integral waterproofing additive to reduce permeability and ultimately reduce the deteriorating effect of exposure to chlorides. Chloride diffusion testing was completed on 50mm diameter by 100mm long cylinders made with 0 and 30% fly ash and w/b ratios of 0.4 and 0.5. A Xypex two-coat application of Concentrate was applied to one set and the Admix C-1000 NF was dosed at 1% and comparisons were made to control samples. At 28 days the specimens were submerged in a chloride bath (1.82% Cl by weight); this is a similar chloride concentration typically found in sea water. The chloride distribution was measured at 1, 3, 6 and 9 months from initiation; this was done by cutting the cylinders in 10 mm layers and ground to measure the chloride content in the powder. Results for both the Portland cement and fly ash mix designs indicated that there was a reduction in chloride penetration depth and a lowering of the chloride diffusion coefficient of the Concentrate treated specimens compared to the controls. There were similar results for the Admix treated samples. It was evident that with longer exposure time, the surface chloride content will increase; again the Xypex treated specimens showed a reduction in surface chloride content over time when compared to non-treated samples.

CSN 73 1326 *"Accelerated Corrosion Testing of Concrete Treated with Admix C-1000 NF", Betonconsult, Building Materials Testing Laboratory, Prague, Czech Republic* CHEM-136

Accelerated corrosion testing was undertaken on 10 - 150mm square cubes; 7 that contained Admix C-1000 NF and 3 non- treated control samples. All specimens were cast utilizing C30/37 classified concrete and saturated with water, surfaced dried and weighed prior to exposure to highly concentrated sulfate solution (i.e. 36,000mg/ℓ) for 60 days. Following this, all samples were weighed and a visual examination of surface deterioration was performed. The samples containing the Admix C-1000 NF measured a weight loss between 38.6 and 90.5g/m^2; a visual examination showed only localized minor deterioration at the edges. The control samples measured a mass loss between 2,473.0 and 3,693.3g/m^2; a visual examination documented significant surface deterioration over the entire surface of the cubes. Based on this testing, there is clear evidence of the effectiveness of the Xypex chemistry to provide exceptional resistance to concrete even when exposed sulfate concentrations well beyond expected levels.

"Acid Resistance of Mortar Coated with Xypex Concentrate or containing Xypex Admix C-1000 NF", Construction and Maintenance Technology Research Center (CONTEC), Sirindhorn International Institute of Technology (SIIT) - Thammasat University, Bangkok, Thailand

CHEM-137

The acid testing regime is part of an extensive program to determine the benefit of using the Xypex treatment both as a coating and as an integral waterproofing additive to reduce permeability and ultimately reduce the deteriorating effect of concrete exposed to acid attack. Other deterioration mechanisms tested include: carbonation and chloride ion diffusion as well as autogenous and drying shrinkage. For the testing of the Xypex Concentrate coating, five sets of mortar specimens were prepared, including controls (uncoated). The specimens were 50 x 50 x 50mm with varying cement types (cement only, and 30% fly ash replacement) and different water-to-binder (w/b) ratios (0.4 and 0.5). The first set (uncoated specimens) were seal cured for 7 day and then submerged in a 5% solution of H_2SO_4. The second, third & fourth sets were coated at ages of 1, 3 & 7 days and then seal cured for 3 days prior to being submerged in a 5% solution of H_2SO_4. The specimens from the fifth set were coated at 3 days following casting and seal-cured for 7 days before also being submerged in a 5% solution of H_2SO_4. This solution was selected to simulate the aggressive environment in a sewer system; the pH was regularly monitored and maintained to be not greater than 0.54 pH during submersion. The specimens were first weighed (SSD) prior to submersion and then at regular intervals during a 12 week period to determine mass loss. Photographs were also taken during the testing period to record changes in surface appearance. The weight change of a mortar specimen in percentage relative to its initial weight was used to indicate amount of deterioration. In all instances the untreated specimens had higher weight loss than the specimens coated with Xypex Concentrate. It was evident from the results that the crystalline coated specimens had a significant influence on enhancing the durability of the mortar specimens. The effect of a lower w/b ratio and increased fly ash content in conjunction with the Xypex crystalline coating provided the best overall acid resistance. With regards to the second phase, a comparison of mortars with and without the Xypex crystalline additive (C-1000 NF) was conducted utilizing controls (both cement only and fly ash concrete with varying a w/b ratio of 0.5) compared to samples containing a 1% Admix C-1000 NF in a cement-only mortar and in a concrete with 30% fly ash content both with a 0.5 w/b ratio. A similar submersion regime was carried out as per the coating specimens. At 12 weeks the Xypex Admix treated specimens reduced the weight loss by 48% in the case of the cement-only mortar and 53% in fly ash concrete specimens respectively. The results also demonstrated that exposing the Admix treated specimens following 28 days of curing provide better results than 3 or 7 day exposure, although there was clearly still substantial benefit even using a 3 day cure

EN 13529 "*Products and Systems for the Protection and Repair of Concrete Structures; Determination of Resistance to Severe Chemical Attack".*
McGrath Engineering Ltd., Vancouver, Canada CHEM-138

Two coats of Xypex Concentrate were applied by brush at approximately 0.8kg per m^2 with a total cured thickness of 0.9 mm. Following application (at 29 days) samples were exposed to solutions of Sulfuric Acid at 2 & 3 pH for 28 days. At 41 days following the application of Concentrate, other prepared samples were exposed for 28 days to 20% NaOH and 20% NaCl. This testing regime involves a visual examination (utilizing a 18x handheld lens) of the surface for blistering, flaking, cracking and any optical changes; results indicate no effect on the surface of samples exposed to H_2SO_4 (pH 2 & 3), NaOH (pH 11 & 12) or 20% NaCl; there were a few minor surface defects noticeable in the samples exposed to 20% solution of NaOH. Testing for reduction in hardness of the samples exposure to the 6 different solutions was also conducted utilizing Shore Hardness Tester. The results of this hardness test resulted in all samples meeting the requirements of EN ISO 868 24.

ASTM C876 "*Half-cell Test for Corrosion Potential of Uncoated Reinforcing Steel in Concrete Treated with Admix*", Australian Corrosion Consultants Pty Ltd., Victoria, Australia CHEM-141

Xypex Admix was used in the concrete of precast docks in 1995 to provide protection from the exposure to a severely corrosive marine environment within a tidal/splash zone. After 19 years of exposure to this harsh marine environment, a test was commissioned to determine the condition of the slabs with regards to chloride deterioration. To determine this, a series of tests were conducted, including: a visual surface examination, a concrete cover survey, half-cell potential mapping, measuring chloride content and measuring reinforcing continuity. The mix design was S40 (PC only) with a 0.375 w/c ratio dosed with Xypex Admix C-2000 NF @ 4.2kg per m^3. Inspection of the slab's surface indicated very little evidence of deterioration, cracking, spalling or other damage. Using a cover meter to determine concrete cover of the rebar, it was found that the minimum concrete cover was 51mm. In utilizing the Half-cell test method a $Cu/CuSO_4$ electrode was used to measure the half-cell potential. Simply, the electrode measures the voltage at the surface of the concrete; the majority of the slab measured within a range of a -50 mV to -100 indicates <5% probability of corroding. A probe was used along a grid to record across the slab. The results showed that the majority (98%) of the Lascelles wharf's steel reinforcement indicated less than a 5% probably of corrosion. Chloride content was also untaken by extracting 3 cores from the slab to measure chloride content a various depth. The results indicated that the chloride content within the first 15 mm was considerable but decreased dramatically past 15 mm. At 10mm it was 0.5 of % of weight cement; at 30mm chloride content was 0.14 % and at 50mm it was 0.06%; which is negligible (a 0.4% concentration by weight of cement would is deemed to be critical). Using this data from the corrosion profiles and Fick's 2nd law, the corrosion service life has been determined: The calculated residual service life is 164 years. The conclusion of the testing stated that a Xypex crystalline treatment effectively reduces the pores and interconnectivity of pores and is considered as the most reliable method to reduce concrete porosity and permeability; this in turn prevents ingress and penetration of harsh chemicals that attack and deteriorate concrete exposed to an aggressive marine environment.

HB 84-2006 "*Chloride Content Assessment of Concrete Containing Xypex Admix Exposed to 19 years of an Aggressive Marine Environment*", Sharp and Howells Pty. Ltd., Chemical Laboratories, Victoria, Australia

CHEM-142

Three cores were extracted from concrete slabs at the Lascelles Wharf – Geelong Ports, Victoria. The wharf was constructed in 1995 and has provide 19 years of service as a bulk chemical and grain dock that has been exposed to a very aggressive marine environment. The concrete mix design was an OPC 40 MPa mix with 400 kg cement, dosed with Admix C-2000 NF @ 1%; no superplasticizers or water reducer were utilized. A 28 day compressive strength of 65MPa was recorded. Various tests on these extracted specimens, including a chloride content assessment to determine the probability of corrosion; this is based on cement content, environmental conditions and concrete cover (i.e. 51mm). Results were obtained for the chloride content of the three cores at three incremental depths; 0-20mm, 20-40mm and 40-60mm. It was determined that the slabs are not susceptible to corrosion; in fact based on Fick's 2^{nd} law of diffusion, the average time to initiation of corrosion was 164 years. Other performance tests included: visual examination (no deterioration noted); reinforcing Continuity (no discontinuity noted), concrete cover (minimum 51 mm); and Equipotential Mapping (no concerns).

ASTM C876 "*Influence of Xypex Coating System on Residual Service Life of Concrete Structures*" Durability Assessment Section, Xypex Australia **CHEM-144**

A bridge pier in a tidal splash zone was starting to experience reinforcing steel corrosion after +40 years of service. An investigation was conducted to examine the effectiveness of the Xypex coating system on the durability performance of the structure. Three corrosion prediction test methods were conducted before and after application of a) one coat and b) two coats of Xypex. Test methods included corrosion current (galvanostatic pulse transient), corrosion potential ($Cu/CuSO_4$ half-cell) and electrical resistance. After 6 months of surface treatment corrosion rates were reduced by an average of 36 to 51%. Half-cell potentials were less negative and concrete resistance was increased. Corrosion activity level in the structure was reduced considerably.

SEALING CRACKS

Japanese Output Test Methodology *"Permeability Test of Xypex Repair of Heavily Cracked Bridge Deck Subjected to Continuous Load and Vibration",* Construction Bureau of Chubu District, Ministry of Construction, Hokutoh Overpass - National Route 23, Chubu District, Japan CRAK-101

A series of field tests were performed on the concrete bridge deck of the Hokutoh Overpass in Chubu Japan. The purpose of the test was to determine if a Xypex Concentrate treatment would permanently seal the cracks in this dynamic concrete structure. Two sections of the bridge deck were utilized in this test. In August 1994 Xypex Gamma Cure was applied at a rate of 1.2kg / m^2 to one section prior to a brush application of Xypex Concentrate to accelerate the crystalline growth. In July 1995 (10 months following application) testing was initiated on 10 cores (10cm in diameter & 20cm long) extracted from the decks. The Xypex treated section and the untreated section were both tested. A series of tests were conducted on the samples, including permeability, compressive strength and scanning electron microscopy (SEM). Six samples were placed in the testing apparatus with the treated surface opposite to the pressure side. Samples were then subjected to a hydrostatic pressure of 2kgf / cm^2 (25m water head) for 16 hours to measure any leakage or output. The samples treated with Xypex Concentrate had some initial minor leakage but this gradually decreased and stopped entirely. In contrast, the group of untreated specimens had an initial outflow reaching almost 5 ml/sec (300ml/min) and due to the amount of leakage, it was assumed that the water flow through the cracks in these untreated samples was constant.

ASTM C856-88 *"Standard Practice for Petrographic Examination of Hardened Concrete"*, Setsco Services Pte, Ltd., Singapore CRAK-103

A number of cores were extracted from a concrete deck at various intervals (3, 10, 14 and 20 days) after application of the Xypex coating. The slab had developed numerous hairline cracks and a petrographic examination of the cores was undertaken to determine the crack sealing capabilities of the Xypex treatment. This included both a visual inspection and a microscopic analysis using a polarizing and fluorescent microscope (PFM) under transmitted and reflected light of thin sections sawn from the core. The results of the visual inspection of the extracted core samples showed evidence of cracks with various widths typically along the whole length of the core. Typically the cracks were widest at the top surface. A hardener was noted in the top 9-10mm of the core, while the deeper layers of the core consisted of normal concrete. A steel bar was observed 74mm below the top surface. The concrete appeared homogeneous, with low voids (@ 0.5%) and no sign of damage was observed. Thin sections were taken from each core in order to examine hairline cracks utilizing a polarizing and fluorescent microscope (PFM). In each case, there was evidence of the Xypex crystalline structure in the cracks to a depth of about

20mm. Photographs taken at this depth at 100 x magnification showed the Xypex crystalline structure had reduced the width of the cracks dramatically.

"Effectiveness of Xypex Concentrate in Sealing Cracks in Concrete", Department of Technology, Civil Engineering Branch, Hosei University, Tokyo, Japan CRAK-104

Concrete samples were cast with a diameter of 30cm and a height of 20cm. Samples were air cured and then cracks measuring 0.1 mm width were created at 5 days age. Samples were then placed in an apparatus and sealed in place using an epoxy. Using a pressure of 2kgf / cm^2 water flow rate through the crack was measured both before and after Xypex Concentrate application to the downstream side of the crack. The water test was performed on specimens at 7 days and 28 day from casting on Xypex treated and control samples. No flow reduction was reported for control samples. Water leakage through the treated specimens decreased gradually and at 80 hours, all water leakage had ceased. The time of coating application (7 or 28 days) did not affect the sealing performance.

"_Testing of Xypex Admix's Ability to Seal Cracks at Monash University Car Park",_ Hanson Yuncken Testing Authority, Melbourne, Australia CRAK-107

Concrete cores were extracted from an Admix treated slab of a car park located at the Monash University in Melbourne. Each of the 4 sample cores had a section of horizontal re-bar and a vertical crack running either totally through it or the majority of the depth of the specimen. A 350mm long PVC standpipe was epoxied to the top surface of each of the samples. The standpipe was maintained with water to the 300mm level for a constant water head. The samples were monitored regularly for leakage. Samples marked No. 2A and 4 showed significant reduction of leakage at 4 days and there were no signs of leakage within the first week; Sample 2 showed notable leakage at 8 days, but within 4 weeks of exposure to the water pressure, all leakage had ceased. A major concern was whether there was evidence of corrosion to the rebar exposed to water; it was determined that the effectiveness of the Xypex in sealing of the concrete cracks prevented any such damage.

ASTM C1585 and ASTM C1202 "Evaluation of s_elf-healing capability of self-compacting concrete made with blast-furnace slag cements activated by the Xypex crystalline catalyst",_ Department of Aeronautical Infrastructure Engineering, Instituto Tecnologico de Aeronautica, Sao Jose dos Campos, Brazil. CRAK-109

Tests were completed on concrete samples with and without Xypex Admix (dosed at 2.5% of cement content), using three types of Brazilian commercial cements (i.e. plain Portland, blast furnace slag cement and slag-modified

Portland). Microcracks were induced by using a press and loading to 90% of ultimate compressive strength, followed by water immersion to trigger self-healing then samples were evaluated in the laboratory at 28, 56 and 84 days. Testing included: mechanical recovery (strength and ultrasonic pulse velocity) and watertightness recovery (sorptivity and rapid chloride permeability); these tests were used to assess the degree of self-healing. Blast furnace slag cements were found to self-heal slower than the other cements but eventually had the greatest self-healing. Xypex Admix improved self-healing (mechanical and watertightness recovery); the effect was greatest for the blast furnace slag concrete specimens treated with the Admix.

"*Testing of Xypex Admix C-1000 NF Crack Healing Capabilities" CH Karnchang (Lao) Company Ltd., Xayaburi Laboratory,* Ban Xieng Yeun, Vientiane, Laos **CRAK-110**

A dam on the Mekong River in Lao is being constructed; to support the use of Xypex Admix C-1000 NF in the concrete, "crack sealing testing" was required by the owners to substantiate claims that the Admix would self-heal static cracks up to 0.4mm. Large concrete panels (3 Admix treated & 3 controls) were created; the Admix dosage was based on 0.8% Admix C-1000 NF (i.e. 2.32kg per m^3 / 33 lbs./$in.^2$) of the total cementitious content of the concrete. Samples were water-cured for 5 days. Force was applied to all panels at the mid-point and pressure was applied to create cracks that radiated the completed depth of each panel. Crack widths on the Xypex Admix treated panel were measured at 3 specific locations and recorded widths of 0.2mm (0.008 in.), 0.6mm (0.024 in.) and 0.38mm (0.15 in.), although cracking up to 2.0mm (0.8 in.) was noted on the Xypex treated panels. The cracks on the control panels measured at 2 points recorded widths of 0.08mm (0.003 in.) and 0.4mm (0.016 in.); the largest crack on these control panels was measured at 1.2 mm (0.47 in.). Reservoirs were then formed over the cracked areas to hold water for the testing of crack sealing. During the testing, water levels were consistently maintained. Initial observations indicated drips typically every second from the underside of the cracks. It was recorded that at 4 days all dripping ceased from the cracks of the Xypex treated panels, while leaking continued through the control slab until the end of the test period (25 days). It should be noted that the Xypex Admix sealed cracks well beyond the 0.4mm (0.016 in.) width. SEM photographs taken magnifications of 500X, 1000X & 3000X clearly illustrate development of the Xypex crystalline formation. Additional performance testing was undertaken in conjunction with this crack testing, namely measuring compressive strength and SEM evaluation of crystalline structure. Testing at 28 days recorded average compressive strength results for the controls at 42.9MPa and for the Xypex treated concrete 46.6MPa, a difference of 3.7MPa or an increase in strength of 8.6%.

SCANNING ELECTRON MICROSCOPY

***"An Enhancement in the Nature of Concrete with a Multiplicative Cement Crystal-Type Concrete Material",* Central Research Laboratory of Nikki Shoji in association with Hosei University, Japan SEM-100**

A concrete block measuring 60cm (W) x 70cm (L) x 40cm (H) was cast. Xypex was applied to the block and cured. The block was left outdoors for approximately 1 year. A specimen for observation by SEM was a core of concrete with a length of 40cm cut perpendicularly to the Xypex treatment. The cylinder was then cut into 18 pieces of equal length and numbered for reference purposes. SEM measurement was carried out by using Nihon-Denshi Corporation's Super Probe 733. Observation of the crystal growth was made at a 20x magnification factor. The crystal growth was then photographed with a 1000x magnification factor. Photographs were taken at various depths (10cm, 20cm & 30cm) from the surface of the Xypex application. It was noted that the crystalline structure was most dense in the photographs taken of the concrete located closest to the treated surface. It was also noted that there was evidence of the Xypex crystalline growth in the concrete at 30cm from the treated surface. SEM photographs of an untreated sample were also undertaken, showing no evidence of crystallizing formation.

***"Observing and Photographing the Xypex Crystalline Structure within the Concrete",* Central Research Laboratory of Nikki Shoji in association with Hosei University, Japan SEM-101**

This is a second SEM test carried out by the Central Research Laboratory of Nikki Shoji. A cylindrical concrete test specimen was treated with a slurry coating of Xypex Concentrate and cured with a water mist spray for 10 days. The opposite (untreated) end of the test piece was then immersed in shallow water for 14 days. An untreated control sample was sheared through at 50mm below the surface and a SEM photograph was taken of the sheared face. Precipitated Ca (OH2) Calcium Hydroxide together with cubic and rhombic particles was visible. The sample treated with Xypex was similarly sheared through at 50mm below the treated surface and a SEM photograph was taken to illustrate considerable crystalline growth at the initiation phase of the Xypex treatment (i.e. at 14 days following application). A SEM second photograph was taken of this sheared surface (i.e. 50mm from the treated surface) 26 days after the application of Xypex Concentrate. A dense, fully developed crystalline structure had formed within the capillary tracts of the concrete to completely block the flow of water.

Scanning Electron Microscopy Testing of Xypex Repair of Heavily Cracked Bridge Deck Subjected to Continuous Load and Vibration Construction Bureau of Chubu District, Ministry of Construction, Hokutoh Overpass - National Route 23, Chubu District, Japan SEM-102

A series of site testing including Scanning Electron Microscopy (SEM) was performed on samples from the concrete bridge deck of the Hokutoh Overpass in Chubu Japan. Two sections of the bridge deck were utilized in this test. Xypex Gamma Cure was applied to one section as an accelerant prior to a brush application of Xypex Concentrate at a rate of 1.2 k / m^2. 10 months following application, testing was initiated as 10 cores (10 cm in diameter & 20 cm long) were extracted from the decks, including both the Xypex treated section and the untreated section and specimens for SEM testing purposes were cut from the cores. Scanning Electron Microscope (Model EMA-733) was used with a voltage of 29KV, 1 x 10-10A. The 10 micron voids were first examined under a magnification of 20x's. A SEM photograph was taken at a magnification of 1000x. An increase of crystals can be observed in cracks in the Xypex Concentrate treated specimen. The untreated sample only the gel wall is observable. It was clear from this SEM testing that there was increased crystalline development in the cracks and by associating this evidence with the permeability testing it is clear that the Xypex treatment was effective in improving the durability of the concrete samples and hence a waterproofing effect resulted.

SEM *"Scanning Electron Microscopy on Xypex Admix C-2000 Modified Specimens",* Setsco Services, Pte. Ltd, Singapore SEM-104

Cores measuring 150mm diameter by 900mm long were extracted from Marina Square project site in Singapore. This included a control and a core from a Xypex Admix C-2000 NF treated area that had been dosed at 0.9% by weight of OPC. The requirement was to conclusively identify the presence of the Xypex crystalline structure. SEM images were taken at age 28 days of both the controls and Xypex treated specimens. The unique Xypex crystalline structure is clearly evident on the SEM images of the Xypex specimens.

SEM *"Scanning Electron Microscopy on Xypex Admix Modified Specimens",* Australian Centre for Construction Innovation, University of New South Wales, Sydney, Australia SEM-105

Three distinctly different concrete mortars dosed with Xypex Admix were examined to determine evidence of crystalline growth. Type-1 samples contained 60% slag blended cement and 0.8% Admix C-1000NF; they recorded a compressive strength of 50 MPa at 28 days and were then submerged in seawater for two years prior to being tested by SEM. Type-2 samples contained 30% fly ash blended cement and 1.2% Admix C-2000 NF; at 28 day the recorded a strength of 65MPa; they were approximately 8 month old when examined by SEM. Type-3 samples contained 38% slag blended cement and 0.8% Admix C-1000NF and recorded an average 47 MPa strength at 28 days; these samples were approximately 12 month old when examined by SEM. All samples were sliced and split to enable SEM examination using a variety of magnifications between 500x and 5000x. Characteristic threadlike Xypex crystalline growth was observable on all samples modified with the Xypex Admix. The crystalline structure is evidence of the reactions of the Xypex chemical with not only Portland cement concrete but is also significant in that it demonstrates the reactions of the Xypex chemistry with fly ash and slag blended cements.

SEM *"Scanning Electron Microscopy on Concrete Cores"*, (Breidbalakvisl Bridge), Hönnun Ltd. - Consulting Engineers, Reykjavik, Iceland
SEM-108

Core samples were extracted in 2005 from a bridge pier to which Xypex Concentrate had been applied in 1993 to determine the long-term effectiveness of the Xypex treatment. The bridge was constructed in 1972 and exposed to a relatively aggressive environment. Permeability testing, chloride penetration resistance testing and evaluation of crack sealing ability of the Xypex coating were also undertaken. The researchers concluded that there was evidence of Xypex crystallization with SEM photography taken of pores near the surface clearly showing the Xypex crystalline structure filling the pores. 20x and 40x magnification of different sized pores were photographed.

SEM *"Scanning Electron Microscopy on Xypex Treated Specimens"*, Electricity Generating Authority of Thailand, Ban Pakong Power Station Scientific & Technological Research Equipment Centre (STREC) Chulalongkorn University, Thailand. . SEM-111

This thermoelectric power plant was construction in 1982 and expanded in 1993 and 2009. The cooling towers were suffering from severe chloride attack, to rehabilitate this structure, Xypex Concentrate and Modified surface coating were applied to the surface of 30,000m^3 (35,879 yd^3). To confirm the crystalline reactions and development within the concrete, 8 days following the treatment, cores were extracted at depths of 30mm (1.2 in.) and subject to scanning electron microscopy. Even in this relative short period from application, there was clear evidence of the development of the unique Xypex crystalline formation.

SEM *"Scanning Electron Microscopy on Xypex Treated Specimens"*, Electricity Generating Authority of Thailand, Ratchabury Power Station Scientific & Technological Research Equipment Centre (STREC) Chulalongkorn University, Thailand. . SEM-113

The 4 year old roof deck of the cooling tower was treated with a two-coat application of Concentrate and Modified to protect it from chloride attack. Concrete cores were extracted 28 days following application at a depth of 20-25mm (@ 0.80 in.) and subjected to microscopic examination. In the SEM images taken a x1500 magnification at a depth of 20mm (0.79 in.), there was clear evidence of the Xypex crystalline formation only after 28 days following treatment.

SEM *"Scanning Electron Microscopy on Xypex Admix C-1000 NF Treated Specimens", CH Karnchang (Lao) Company Ltd., Xayaburi Laboratory,* Ban Xieng Yeun, Vientiane, Laos SEM-114

A dam on the Mekong River in Lao is being constructed; to support the use of Xypex Admix C-1000 NF in the concrete, the owners requested SEM photographs to substantiate claims that the Admix develop throughout the static cracks. Large concrete panels (3 Admix treated & 3 controls) were created; the Admix dosage was based on 0.8% Admix C-1000 NF (i.e. 2.32kg per m^3 / 33 lbs./$in.^2$) of the total cementitious content of the concrete. Samples were water-cured for 5 days. Force was applied to all panels at the mid-point and pressure was applied to create cracks that radiated the completed depth of each panel. Crack widths on the Xypex Admix treated panel were measured at 3 specific locations and recorded widths of 0.2mm (0.008 in.), 0.6mm (0.024 in.) and 0.38mm (0.15 in.), although cracking up to 2.0mm (0.8 in.) was noted on the Xypex treated panels. The cracks on the control panels measured at 2 points recorded widths of 0.08mm (0.003 in.) and 0.4mm (0.016 in.); the largest crack on these control panels was measured at 1.2mm (0.47 in.). Reservoirs were then formed over the cracked areas to hold water for the testing of crack sealing. During the testing, water levels were consistently maintained. Initial observations indicated drips typically every second from the underside of the cracks. It was recorded that at 4 days all dripping ceased from the cracks of the Xypex treated panels, while leaking continued through the control slab until the end of the test period (25 days). It should be noted that the Xypex Admix sealed cracks well beyond the 0.4mm (0.016 in.) width. SEM photographs taken magnifications of 500X, 1000X & 3000X clearly illustrate development of the Xypex crystalline formation.

SEM *"Scanning Electron Microscopy on Xypex Admix C-1000 Treated Specimens",* Jinghong Hydropower Station, Kunming Survey and Design Institute, Yunnan Key laboratory, Hydropower SinoChina, Yunnan Province, China SEM-115

A dam on the Lancang River in Yunnan Province of China utilized Admix C-1000 in the upstream face in roller compacted concrete @ 1.5% dosage rate of the of the 108 m high dam and Concentrate was applied to plant rooms and Patch'n Plug was utilized to prevent leakage through joints and crack in the corridors. Samples were tested throughout the 5 year construction period for permeability, strength (compressive, flexural and tensile) and freeze-thaw durability; all test results reported enhance performance of the Xypex treated concrete. SEM testing was performed and confirmed the presence of the unique Xypex dendritic crystalline structure which was compared to images of untreated reference concrete that showed no similar structure.

AIR PERMEABILITY TESTING

"*Test of Air Permeability*" Department of Concrete Construction and Bridges, Faculty of Civil Engineering, Bratislava, Slovak Republic
AIR-100

Cored concrete samples, 100mm diameter and 30mm long, were tested for air permeability. Samples were dried up to reach a stable weight of 105^{o}C and were then left to cool down to the temperature of the testing chamber. The samples were placed into sealed testing cells and air was forced through the concrete cylinders using a pressure of 100kPa. The volume and time period for air to pass through each sample was measured. The samples were then treated with a two-coat application of Xypex Concentrate; moist cured for 2 day and then air cured for 18 days. The samples were again dried up at a temperature of 105^{o}C, left to cool down and then placed into the sealed cell. Air was again forced through the concrete cylinders using a pressure of 100kPa. The flow rate of air passing through each sample was measured. The Xypex treated samples reduced the air permeability in half compared to that of the untreated samples.

POROSITY TESTING

Porosimetric Testing, Klokner Institute, Czech Technical University, Prague, Czech Republic **PORS-100**

Two concrete samples were prepared to the standard Class B 20 (STN 732400). One sample was treated with a single coat application of Xypex Concentrate and the other remained untreated for reference purposes. Both samples were subjected to a Porosimetric testing by means of a high-pressure porosimeter, which can apply up to 100MPa of pressure to determine the size of pores between 7.5 and 7,500mm. The average pore size of the untreated sample was 41.6mm^3 /g, and 25.2mm^3 /g for the treated sample. It was also shown that there was a decrease in the overall porosity of the Xypex treated sample to almost half that of the untreated sample.

FREEZE-THAW DURABILITY

ASTM C 672 *"Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to De-icing Chemicals"*, Twin City Testing Lab, St. Paul, USA **FREZ-100**

The effects of exposing Xypex treated concrete to 50 cycles in the presence of de-icing chemical, was evaluated utilizing the ASTM C 672 test procedures. It was found that Xypex treated samples restricted chloride ion concentration to below the level necessary to promote electrolytic corrosion of reinforcing steel.

Visual examination of the Xypex treated samples exposed to 50 freeze/thaw cycles showed a marked decrease in surface deterioration compared to the untreated samples.

JIS A 6204 *"Concrete Freeze/Thaw"*, Japan Testing Center for Construction Materials, Tokyo, Japan FREZ-101

The resonating frequency of both untreated and Xypex Concentrate treated concrete samples were measured throughout 435 freeze / thaw cycles each lasting 3 – 4 hours with the temperature fluctuating from -5°C → 18°C → -5°C. At 204 cycles, the Xypex-treated samples showed 96% relative durability compared to 90% in the untreated samples. At 435 cycles, the Xypex-treated samples measured 91% relative durability compared to 78% in the untreated reference samples.

ASTM C 666 *"Freeze/Thaw Durability",* Independent Laboratory, Cleveland, USA FREZ-102

After 300 freeze/thaw cycles, the Xypex Admix treated samples which were air entrained indicated 94% relative durability.

ASTM C672 "Scaling Resistance of Concrete Surfaces Exposed to De-icing Chemicals". McGrath Engineering Ltd., Vancouver, Canada FREZ-104

Three concrete mixes were cast utilizing CSA A23.1 Class C1 mix design, including a control, concrete with a 2% dosage of Xypex Admix C-1000 and concrete containing an accelerator as well as the Admix C-1000. Sufficient air entrainment was used to produce freeze-thaw resistant concrete. Following casting, all samples were placed in a moist curing chamber for 14 days and then stored in air for an additional 14 days at approximately 23°C and 50% R.H. The samples were exposed to 50 freeze-thaw cycles (i.e. samples placed in a freezing environment for 16 to 18 hours, then removed for 6 to 8 hours into an environment with approximate temperature of 23°C and a relative humidity of 50%). The Xypex treated samples had less mass loss than the control concrete. There was also little or no visual evidence of scaling for all three samples.

JUS U.M1.016 and JUS U.M1.055, "*Study on the effects and efficacy Xypex Admix C-1000 NF when exposed to Freeze Thaw Conditions in the Presence of De-Icing Chemicals"*, Institute for Materials and Structures, University of Sarajevo, Faculty of Civil Engineering, Sarajevo, Bosnia and Herzegovina. FREZ-105

Concrete samples containing Xypex Admix C-1000NF at a dosage rate of 1.2% were tested for freeze thaw resistance using two standard procedures. Design strength for the concrete was 40 MPa using a CEM II/B-W 42,5N cement (20-

35% high-lime fly ash), super plasticizer and air entraining agent. Procedure JUS U.M1.016 runs concrete samples through 250 freeze thaw cycles with water only and then checks water absorption and loss of compressive strength. The Xypex sample showed a 71% lower loss in compressive strength versus the control concrete. The Xypex sample had 13% lower water absorption. Both of these results indicate Xypex Admixture improved the concrete's resistance to freeze thaw. Procedure JUS U.M1.055 requires soaking concrete samples in 3% sodium chloride solution for 7 days. Following exposure, the samples were subjected to 25 freeze-thaw cycles, on cycle consisting of exposure to temperatures -20^{o}C (+ or –2^{o}C) for 16-18 hours and thawing at a temperature of 20^{o}C (+ or –2^{o}C) for 6-8 hours. Samples were evaluated as to visual deterioration (i.e. flaking) re loss of mass and the depth of deterioration. The untreated specimens showed after 30 cycles small flaking and deterioration up to a depth of 1mm. Xypex treated concrete exhibited no such flaking and no measurable depth of deterioration.

EN 12390-5 *"Testing Hardened Concrete; Resistance to Freeze / Thaw Exposure Measured by Flexural Strength",* Faculty of Civil Engineering, Czech Technical University of Prague, Czech Republic FREZ-107

Samples of a C30/37 XF3 concrete mix design dosed with Xypex Admix C-1000 NF dosed at 1.5% were tested for resistance to freeze / thaw damage. The test included exposure to water and 150 freeze/thaw cycles. The effectiveness of the C-1000 NF samples to prevent deterioration was measured utilizing the coefficient of frost resistance, a ratio between flexural strength of samples after 150 cycles and reference samples, was 0.88 (the norm requires 0.75).

***"Testing Hardened Concrete. He Effect of Freeze / Thaw Cycling of Mass Loss"* Institute for Materials and Structures, University of Sarajevo, Faculty of Civil Engineering, Sarajevo, Bosnia and Herzegovina. FREZ-108**

Samples of a C30/37 XF3 concrete mix design dosed with Xypex Admix C-1000 NF dosed at 1.2% utilizing an air entrainment were tested for resistance to freeze / thaw damage. The samples were evaluated by measuring mass loss for resistance to freeze / thaw damage and exposure to a 3% NaCl solution. After 30 freeze / thaw cycles, the average weight loss of the samples without Xypex was 0.2mg/mm^2, while the Admix treated samples had no measurable weight loss.

JUS U.M1.016 and JUS U.M1.055, "*Study on the effects and efficacy Xypex Admix C-1000 NF when exposed to Freeze Thaw Conditions in the Presence of De-Icing Chemicals*", Gradis Teo, Ljubljana, Slovenia FREZ-109

Three samples containing Admix C-1000 NF were exposed to 25 freeze-thaw cycles. Samples were age 34 days at the start of testing. Various measurements were taken at 5 cycle intervals, including mass loss and percentage of surface damage. At the conclusion of 25 cycles, total mass loss for the 3 samples was 0.02 mg / mm^2, well under the allowable limit of 0.2mg / mm^2.

***EN 12390-9 / EVS 814 "Testing Hardened Concrete Containing Xypex Admix C-1000: To Determine. Freeze-Thaw Resistance",* AS TEEDE TEHNOKESKUSE Laboratoorium, Tallinn, Estonia FREZ-110**

Four replicate 150mm concrete cubes were cast using a C20.25 mix design containing a 2% dosage of Xypex Admix C-1000 and utilizing a w/c ratio of 0.55; 4 controls were also cast. All specimens were cured for 7 days and then cut to a thickness of 50mm at 14 days. Samples were encased in a rubber sleeve to ensure that the refrigerant remains on the exposed surface. Three days prior to testing, distilled water was poured over the surface and was replaced with a 3% solution of sodium chloride just before being placed in the freezer. All samples were covered to prevent evaporation of this solution. They were then exposed to repeated 24 hour cycling in and out of the freezer. After cycles 7, 12, 28, 42, 56, 70, 84, 98 and 112 the amount of weathered material from test sample surfaces was removed by brushing and weighed. After each measurement, a fresh NaCl solution was placed on top of the samples before again being placed in the freezer. At the conclusion of 112^{th} cycle the Admix C-1000 samples recorded an average loss of mass of 0.66 kg/m^2 compared to the non-treated controls at 0.77$kg/m^{2.}$

RADIATION RESISTANCE

U.S.A. - Standard No. N69 "Protective Coatings for the Nuclear Industry", Pacific Testing Labs, Seattle, USA RADN-100

Xypex treated samples were exposed to 5.76 x 104 rads of gamma radiation. Visual examination, photographic documentation, and adhesion testing (ASTM 3359-78) was performed on the Xypex treated sample. There was no indication of any visible change or damage due to exposure to gamma radiation.

Japan Atomic Energy Research Institute (JAERI) *"Exposure to Radioactive Solution 137Cs"*, Tokyo, Japan RADN-101

JAERI performed comparative testing on cement mortar treated with Xypex to that of untreated reference samples to determine if there is a difference in the penetration of the radioactive solution 137Cs. The test results demonstrated that the penetration of radioactive 137Cs was reduced in the cement mortar specimens that were coated with the Xypex. At a depth of 5 to 7 mm the concentrate of the radioactive solution 137Cs was about 10 times less in the Xypex treated samples than the untreated sample.

CARBONATION RESISTANCE

***"Evaluating the Effectiveness of Xypex Treatment to Suppress or Limit Carbonation"*, Building Materials Testing Center, Tokyo, Japan**
CARB-100

Concrete samples, both coated with Xypex Concentrate and an untreated sample (for control purposes) were maintained at 30°C, 60% Relative Humidity, and in a 5% CO_2 environment for a 60 day period. At the conclusion of the exposure period, the Xypex treated samples recorded a depth of penetration of 8.4mm, compared to the untreated specimens at 14.4mm. There was a reduction of carbonation penetration with the Xypex sample by approximately 80% compared to the untreated specimen.

EN 13295 - Modified Test Procedure *"Products and Systems for the Protection and Repair of Concrete Structures – Determination of Resistance to Carbonation"*, McGrath Research & Testing Ltd., Vancouver, Canada **CARB-101**

Concrete liners for steel pipe samples were obtained from Libya's Great Man-Made River Project. All specimens had been pre-carbonated on one side due to the environment from which they were extracted. Some of the samples were coated with various Xypex materials, including Xypex Concentrate, and a modified Concentrate coating containing polymers; other samples were left uncoated for controls. A carbon dioxide rich atmosphere was created in a test chamber (i.e. 4% $C0_2$ in air, 25°C temperature and 60% relative humidity) in which the samples (treated and untreated) were placed for 1 month. Following exposure, all samples were removed, split transversely and tested for depth of carbonation by phenolphthalein indicator. Results indicated that the Xypex treated samples would reduce the rate of carbonation between 2.5 and 3 times that of the untreated controls.

"Testing of Effects of Xypex Modified and Measures to Increase Effectiveness of Xypex Admix", Slovenska Akadémia Vied, Bratislava, Slovak Republic **CARB-102**

In Phase I of this test program samples measuring 40 x 40 x 160mm coated were coated with one or two coats of Xypex Modified along with non-treated controls and were exposed to a carbon dioxide rich atmosphere for 14 days. Results indicate that the single coat application of Modified reduce the rate of carbonation by 27.2%, while the two-coat application reduce the rate by 61.9% compare to the controls. Phase II evaluated the influence of the application of a single Modified coating onto fully carbonated concrete specimens which were subsequently re-alkalized by curing samples in normal air with a 98% relative humidity at 20° to 25 °C. After re-alkalization, the samples were again exposed to carbonation for 14 days and measurements of depth of carbonation were taken. Results indicate that there was a high rate of carbonation on these samples, up to 3 times faster than for non-re-alkalized mortar. Several mix designs involving Xypex Admix C-1000 (at a 4% dosage rate) in mortar samples were also evaluated for exposure to carbon dioxide. Calculation showed 1.4 to 1.6 times reduction in the rate of carbonation in mortars containing the Xypex Admix.

"Determination of CO_2 diffusion through concrete treated with a coating of Xypex Concentrate", **Klokner Institute of the Czech Technical University, Prague, Czech Republic CARB-103**

Xypex Concentrate was applied to a concrete substrate at a rate of 0.8kg per m^2 and 150mm diameter x 9mm thick specimens were extracted. The samples were then placed in a climate controlled box (30^{o}C and 70% - 85% R.H. & a 50% CO_2 environment). The purpose of the test program was to measure the depth of penetration of the CO_2 over a period of 10 days. Results indicated that the Xypex treatment provided carbonation protection to the concrete substrate equivalent to 3 times greater than the usual requirement which they conclude (based on this test) is an "extraordinarily effective anti-carbonization coating system".

RILEM CPC-18, *"Carbonation Resistance of Concrete with Xypex Concentrate Coating",* Construction and Maintenance Technology Research Center (CONTEC), Sirindhorn International Institute of Technology (SIIT) of Thammasat University, Bangkok, Thailand. CARB-105

The carbonation testing regime is part of an extensive program to determine the benefit of using the Xypex Concentrate coating treatment to reduce permeability and ultimately reduce the deteriorating effect of carbonation to concrete. Portland cement and 30% fly ash replacement concrete mixes (w/cm = 0.4, 0.5 and 0.6) were cast into 100 mm cubes. Control and Xypex Concentrate coated samples were carbonated in an accelerated carbonation chamber at 40ºC, 55% rh and 4% CO2 was utilized. One set of samples was first carbonated then coated with Xypex Concentrate in order to model old concrete already damaged by carbonation. The average depths of carbonation were measured at 28, 56, 77 and 91 days by splitting the specimens and spraying with a phenolphthalein solution on the freshly broken surface. The depth of carbonation of the Xypex Concentrate coated specimens was reduced by 35 - 40% compared to the controls. For the specimens coated with Xypex Concentrate after carbonation, further carbonation was nearly halted and in one sample reduced.

COMPRESSIVE STRENGTH

ASTM C 39 *"Compressive Strength of Cylindrical Concrete Specimens"*, HBT Agra, Vancouver, Canada COMP-100

Concrete samples containing Xypex Admix at various dosage rates (1%, 2% and 5%) were tested against an untreated concrete control sample. Compressive strength test results after 28 days indicated a significant strength increase in the samples incorporating Xypex Admix. The compressive strength increase varied between 5% and 20% (depending on the Xypex Admix dosage rate) over that of the reference sample.

ASTM C 39 "*Compressive Strength of Cylindrical Concrete Specimens*" Kleinfelder Laboratories, San Francisco, USA COMP-101

Kleinfelder evaluated the compressive strength of concrete containing the Xypex Admix. At 28 days the compressive strength test for the Xypex Admix sample measured 7160 psi (49MPa) as compared to the reference sample at 6460 psi (44MPa), a 10% increase. Compressive strength results performed at 56 days indicate that the concrete sample containing the Xypex Admix reached 8340 psi (57MPa) as compared to the reference with 7430 psi (51MPa) at 12% increase.

BS 1881: Pt 120: 1983 "Compressive Strength Testing", Setsco Services Pte. Ltd., Singapore COMP-103

Compressive strength testing in accordance with British Standards (BS) 1881: Pt 120: 1983. Testing was performed on 15 Xypex Admix C-2000 treated and untreated cubes measuring 150 x 150 x 150mm at 1, 3, 7, 28 and 56 days. As well, compressive strength testing was performed at 7 and 28 days on two 100 x 900mm cylinders (one treated and one untreated). The Xypex treated samples exhibited between 7 and 14% strength increase at 28 days over that of the control samples.

***"Evaluation of Compressive Strength of Cylinders"* Mahaffey Associates Pty. Ltd., Rydalmere, Australia COMP-104**

Five concrete cylinders (150mm diameter) containing the Xypex Admix were cast along with similar cylinders with no Admix and other cylinders with a pore blocking additive. At 28 days the control recorded 40.5 MPa, the pore blocker sample 40MPa and the Xypex sample 44MPa (i.e. an 8% increase in compressive strength). Samples were also tested for flexural strength and chloride penetration.

STN 73 1317 *"Determination of Strength of Xypex Admix Treated Samples under Compression"*, Technical Testing Institute of Civil Engineering, Bratislava, Slovak Republic COMP-107

Concrete cube samples measuring 150 x 150 x 150mm were cast using a HV 12 mix design. Six samples were made using I 42.5 Turna n/Bodvou cement and six samples were made using I 42.5 Ladce cement. Three from each batch contained the Xypex Admix and three had no Admix. The average compressive strength for the Turna n/Bodvou samples containing the Xypex Admix was 35.1MPa, while the average strength of the Turna n/Bodvou reference samples was 30.2MPa. The average compressive strength for the Ladce samples containing the Xypex Admix was 34.9MPa, while the average strength of the Ladce reference samples was 32.2MPa.

STN 73 1317 *"Determination of Strength of Xypex Admix Treated Concrete Samples",* ARMABETON A.S. Accredited Testing Laboratory, Prague, Czech Republic COMP-108

Fifteen concrete cube samples measuring 100 x 100 x 100mm were cast using a B 20 mix design with 32.5 R Radotin Cement. Three samples were cast for reference purposes. Three samples containing the Admix were cast with the Xypex Admix at 1%, three others at 2 %, three others at 2.5% and three others at 3%. All cubes were broken at 28 days following casting. The average compressive strength for the reference samples was 24.7MPa, while the average strength of the 1% Admix samples was 28.7MPa, 2% Admix samples was 29.9MPa, 2.5% Admix samples was 31.0MPa and the 3% Admix samples was 31.3MPa.

AS 1012.9, *"Compressive Strength of Cylindrical Concrete Specimens",* Australia Centre for Construction Innovation, University of New South Wales, Sydney, Australia COMP-109

Concrete samples containing Xypex Admix C-1000NF & C-2000NF 0.8% and 1.2% were tested against untreated control samples for compressive strength results at 3, 7, 28, and 365 days. All concrete mixes modified with the Admix had higher strength than the controls at all ages. At 28 days the average increase in strength for the Admix samples was 4.3%. The Xypex samples containing a superplasticizer also recorded increased compressive strength results over the control (by up to 8%). Samples containing 20% and 40% fly ash that were modified with the Admix recorded increases of between 6% to 12% at 28 days and 12% to 19% at 365 days over the controls. Slag cement concretes dosed with the Admix also showed an increase in compressive strength. The Admix dosed samples containing a ternary blend of 20% slag & 28% fly ash had higher strength at all ages (e.g. 25% at 3 days & 18% at 28 days).

AS 1012.9, *"Compressive Strength of Cylindrical Concrete Specimens",* Australia Centre for Construction Innovation, University of New South Wales, Sydney, Australia COMP-110

Nine commercial concretes were tested for effects of the Admix on compressive strength of 40MPa concrete (specified for marine applications). The mixes included 3 different Type-GP cements, including a 25% fly ash blend and two slag (38% and 60%) blends along with controls of each for comparison purposes. Xypex Admix C-1000NF (0.8% dosage) that contained 25% fly ash had higher compressive strength results by 22% and 15% at 28 and 91 days respectively. Those samples that were dosed at 1.2% were even higher by 24% to 31% at all ages. The Type-GB 38% slag blend treated with the Admix recorded increases at all ages, although not as significant as the fly as samples. Several of the 60% slag mixes treated with the Admix recorded slightly reduced compressive strength when compared to the controls, although the mix dosed with 1.2% Admix recorded 8% to 11% increased strength over the controls.

AS 1012.9, *"Compressive Strength of Cylindrical Concrete Specimens",* Australia Centre for Construction Innovation, University of New South Wales, Sydney, Australia COMP-111

Four commercial concretes with design strength of 40MPa (specified for marine applications) including Type-GB blended cement with 25% fly ash and Type GB blended cement with 38% slag blend were evaluated for the effects of Xypex Admix C-500NF / C-5000NF at a dosage of 0.5% Admix compared to untreated control samples. The test data for the 25% fly ash mix recorded an increase of 19% at 3 days, 12% at 7 days, 6% at 28 days and 5% at 91 days over the controls. For the Type-GB 38% slag blend treated with the Admix increases in compressive strength recorded 12% at 3 days, 13% at 7 days, 3 % at 28 days and 2% at 91 days. The effects of the Admix are more dramatic in the early ages, which would enable earlier stripping of formwork and acceleration of the construction process.

JISA 1107 *"Compressive Strength Testing of Xypex Repair of Heavily Cracked Bridge Deck Subjected to Continuous Load and Vibration",* Construction Bureau of Chubu District, Ministry of Construction, Hokutoh Overpass - National Route 23, Chubu District, Japan COMP-112

A series tests including Scanning Electron Microscopy (SEM), permeability and compressive strength were performed on samples removed from the concrete bridge deck of the Hokutoh Overpass in Japan. Two sections of the bridge deck were utilized in this test. Xypex Gamma Cure was applied to one section as an accelerant prior to a brush application of Xypex Concentrate at a rate of 1.2kg / m^2. After 10 months, testing was initiated on 10 cores (10 cm in diameter & 20 cm long) extracted from the decks, including both the Xypex treated section and the untreated section. Compressive strength tests were conducted on 3 treated and 3 untreated samples according to JISA 1107. Results indicated that there was an average 28% increase in compressive strength over the untreated samples.

"*Compressive Strength of Concrete Specimens Treated with Xypex Admix*", (Baneasa Airport) Transportation Research Institute, S.C. INCERTRANS S.A. Bucharest. Romania COMP-114

Xypex Admix was used in concrete repairs (measuring 3-5cm in thickness) rehabilitate the deteriorated surface of a platform deck at the Baneasa International Airport in Bucharest. In order to evaluate the effects of the Xypex treatment, cores were extracted and tested for their compressive strength. The cores all had a diameter of 100 mm and varied in length between 115mm and 168mm. An untreated specimen taken from the deck recorded a compressive strength of 35.1MPa, while the specimens treated with Xypex averaged 47MPa, which represents approximately a 30% increase. Splitting tests were also performed. The report also indicates that the concrete repairs bonded well to the substrate and that the breaks typically occurred in the old existing substrate, not the concrete containing the Admix.

***"Compressive Strength of Concrete Specimens Containing ADMIX C-2000",* Instituto Technologico Del Hormigon S.A. (ITH), Buenos Aires, Argentina COMP-115**

Compressive strength testing was performed on cylinders containing the Admix C-2000 dosed at 2% by weight of cement. The concrete mix design (i.e. H30) requires a minimum strength of 350kg/cm^2 at 28 days. The three samples tested containing the C-2000 had an average compressive strength of 487kg/cm^2 at 28 days, which represents approximately a 40% increase in compressive strength over the design mix requirements.

AS1012 Part 9 *"Compressive Strength of Concrete Specimens Containing ADMIX C-2000NF",* Materials Testing & Environmental Services, Boral Construction Materials, NSW, Australia COMP-116

Compressive strength testing was performed on cylinders measuring 100 mm diameter by 200mm in length. One set of cylinders was dosed with the Admix and Grace's Daracem (superplasticizer); a second set eliminated the Admix, while a third set eliminated the Daracem. The design mix used was 40MPa, and breaks occurred at 1, 4, 7, 14, 28 and 56 days. Set one (containing the Admix and Daracem) recorded a 60.0 MPa compressive strength at 56 days. Set two (containing only the Daracem) recorded a 52.5MPa compressive strength at 56 days. Set three (containing only the Admix) recorded a 53.5MPa compressive strength at 56 days. Based on this testing it can be observed that the Xypex Admix, whether used in conjunction with a superplasticizer or not, provide an increase in compressive strength.

ASTM C 109 *"Compressive Strength of Megamix I Coatings"*, James Neil & Associates Ltd., Vancouver, Canada COMP-119

Compressive strength testing was performed at 7 and 28 days. Three different set of Megamix I (50 mm cubes) were evaluated with varying ratio of water to Xycrylic Admix and the amount of liquid to powder ratio. Set one with 2:1 ratio (water / Xycrylic) and a 2:5 ratio (liquid to powder) recorded 24.8MPa (3610 psi) at 28 days. Set two with 3:1 ratio (water / Xycrylic) and a 1.8:5 ratio (liquid to powder) recorded 26.0MPa (3770 psi) at 28 days. Set three with 3:1 ratio (water / Xycrylic) and a 2:5 ratio (liquid to powder) recorded 21.4MPa (3105 psi) at 28 days.

ASTM C 109 *"Strength Testing of Megamix II Mortar Specimens"*, Levelton Engineering Ld., Richmond, Canada COMP-120

Megamix II sample cubes were evaluated for compressive strength, flexural strength and splitting tensile strength. Compressive strength was recorded on two samples each at: 24 hrs - 21.2 MPa / 3080 psi; at 3 days - 38.0 MPa / 5515 psi; at 7 days - 47.2 MPa / 6845 psi and at 28 days -(59.3 MPa / 8600 psi. Flexural strength was also measured at 28 days; results averaged 8.2 MPa / 1190 psi. Splitting Tensile Strength was tested at 28 days resulting in an average measurement of 4.2 MPa / 603 psi.

ASTM C 109 *"Strength Testing of Concrete Specimens dosed with Admix C-1000"*, Levelton Engineering Ld., Richmond, Canada COMP-121

Three concrete mixes were cast utilizing CSA A23.1 Class C1 mix design, including a control, concrete with a 2% dosage of Xypex Admix C-1000 and concrete containing an accelerator as well as the Admix C-1000. Sufficient air entrainment was used to produce freeze-thaw resistant concrete. Following casting, all samples were placed in a moist curing chamber for 14 days and then stored in air for an additional 14 days at approximately 23^{o}C and 50% R.H. Subsequent compressive strength testing showed samples all over 45MPa at 56 days, with the Xypex treated samples having at least 11% increase over the controls.

***"Compressive Strength of Concrete"* Construction and Maintenance Technology Research Center (CONTEC), Sirindhorn International Institute of Technology (SIIT) of Thammasat University, Bangkok, Thailand COMP-125**

The strength testing is part of an extensive program to determine the benefit of using the Xypex treatment both as a coating and as an integral waterproofing additive to reduce permeability and carbonation and evaluate acid resistance, chloride diffusion, autogenous and drying shrinkage. The compressive strength of concrete samples was evaluated at 28 days age for plain Portland and fly ash

(30% replacement) concrete mixes at water to binder ratios of 0.5 and 0.6. The results showed that both the Xypex Concentrate coating (1mm thick) and Xypex Admix C-1000 NF (1% NF Grade) increased the strength of concrete for all mix proportions. The coating increased the strength by 3 to 4% whereas the Admix increased strength by 7 to 8%. The increase in 28 day compressive strength compared to control mixes is illustrated in the following figure:

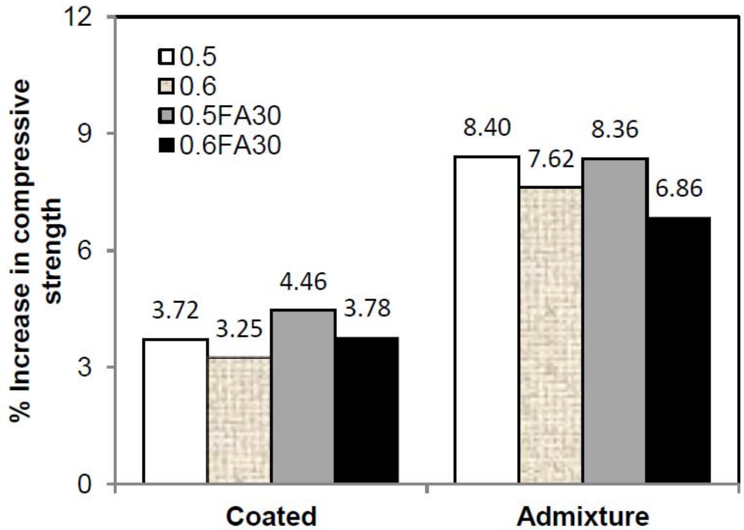

Figure 8. Effect of crystalline materials on compressive strength

ASTM C 109 *"Strength Testing of Concrete Specimens dosed with Admix C-500"*, Levelton Engineering Ld., Richmond, Canada COMP-127

Three concrete mixes were cast utilizing CSA A23.1 Class C1 mix design, including a control, concrete with a 2% dosage of Xypex Admix C-1000 and concrete containing an accelerator as well as the Admix C-1000. Sufficient air entrainment was used to produce freeze-thaw resistant concrete. Following casting, all samples were placed in a moist curing chamber for 14 days and then stored in air for an additional 14 days at approximately 23^{o}C and 50% R.H. Subsequent compressive strength testing showed samples all over 45MPa at 56 days, with the Xypex treated samples having at least 11% increase over the controls.

TENSILE BOND STRENGTH

CSA A23.2-6B *"Tensile Bond Pull-off, Xypex Patch n Plug"*, Metro testing Laboratories Ltd., Vancouver, Canada TENS-100

Tensile Bond Pull-off testing was performed on Patch'n Plug sample cubes measuring 100 mm x 100 mm square. The average test result for 12 samples was 0.8MPa (120 psi). It should be noted that this testing program involved modifying the water / powder mix ratios, evaluating a number of different surface conditions and utilizing Xycrylic Admix in a number of the samples tested. The optimum mix proved to be the samples using a 1:1 ratio of Xycrylic Admix to water and applied to a SSD surface. This sample produced tensile bond "pull-off" strength of 1.1MPa (160 psi).

CSA A23.2-6B *"Tensile Bond Pull-off, Xypex Concentrate & Xypex Modified Coating System",* Metro Testing Laboratories Ltd., Vancouver, Canada TENS-101

Tensile Bond Pull-off testing was performed on the Xypex Concentrate and Xypex Modified coatings applied to concrete pavers. The test results of the samples were 1.49MPa (216 psi). In examining the bond failure, it was noted that the failure occurred to a greater extent in the concrete pavers than in the Xypex coating.

CSA A23.2-6B *"Tensile Strength of Megamix I Coating Samples""*, Metro Testing Laboratories Ltd., Vancouver, Canada TENS-103

Megamix I samples were placed onto a variety of concrete substrates, including: concrete block, coating of Xypex Concentrate cured for 1 day and a coating of Concentrate cured for 4 days. Material was then mixed and placed onto the various surfaces. A 4" (10cm) steel plate was affixed to the Megamix I coating using an epoxy. A tensile load was applied using a calibrated hydraulic ram and frame combination until failure occurred. It was recorded that the samples applied directly to the pressure washed concrete block had average pull-off bond strength of 1.54MPa (220 psi). The Megamix I applied to a one-day cured Concentrate coating recorded average pull-off bond of 1.24MPa (180 psi), while the samples with the Concentrate cured for 4 days prior to applying the Megamix I, recorded a bond strength of 1.18MPa (170 psi).

CSA A23.2-6B *"Tensile Strength of Megamix II Mortar Specimens"*, Metro Testing Laboratories Ltd., Vancouver, Canada TENS-104

Megamix II samples were cast onto concrete slab. The aged concrete surface was pressure washed prior to application using a 1600 psi (11 MPa) spray and dried to SSD condition. Material was then mixed and placed onto slab samples measuring 100 mm x 100 mm by 100 mm thick. Samples were left to cure for approximately 80 days curing in an outdoor environment with relatively cool ambient temperatures. A 4" steel plate was affixed to the Megamix II surface with an epoxy. A tensile load was applied using a calibrated hydraulic ram and frame combination until failure occurred. The average Bond Pull-Off strength of the Megamix II samples was 2.25MPa (326 psi).

ASTM D 7234 *"Direct Tensile Strength of Megamix II Mortar Specimens"*, Metro Testing Laboratories Ltd., Vancouver, Canada TENS-110

Megamix II mortar was applied to prepared concrete panels 24" x 24" x 2" (60cm x 60cm x 5cm) with a design strength of 5500 psi (37.9MPa). The top surface received a steel trowelled finish and was cured with an ACI 308 acrylic membrane-curing compound. Follow a 28 day period the panels the top surface of the panels were mechanically prepared by dry-abrasive blasting to produce an acceptable profile. A control panel was withheld. The surface of the panels were dampened with water to produce a SSD (saturated surface dry) condition immediately prior to applying Megamix II at a thickness of 3/8". The Megamix II coating received a steel trowel finish. The finished coating was then cured with various different methods, including a section with no curing; another section was treated with an acrylic curing compound. Following this, a section of the finished Megamix II coating was sand-blasted, and all surfaces were then treated with an epoxy top coat (Tnemec's Series 435 – a high performance epoxy). The topcoat was then cured for 7 days immediately prior to bond testing. The specimens that were cured properly reported that the average Megamix tensile bond strength was 535 psi (3.7MPa).

ASTM D412-06a (Method A) "*Standard Test Method for Vulcanized Rubber and Thermoplastic Elastomers – Tension",* Advanced Plastic and Material Testing Inc., Ithaca, NY TENS-111

Samples of the FCM 80 membrane were tested for both tensile bond strength and elongation properties. Samples were prepared as per the manufacturer's specifications. The first test evaluated six replicate samples that had been dry cured for 39 days (these were tested dry). The second test evaluated three samples that had been dry cured for 29 days and then wet cured for 32 days (these were tested wet) and tested also 3 samples that had a 28 day dry cure followed by a 22 day wet cure, then a 10 day dry cure (these were tested dry). The first test samples had an average tensile strength of 157 psi (1.08MPa) and 94% at break. The 3 samples from the second test results that were tested while dry indicated an average tensile strength 258 psi (1.78MPa) with a 70% elongation at break. The final 3 sample from this second test that were evaluate wet resulted in a tensile strength of 81.9 psi (0.56MPa) and a 65% elongation at break.

EN 1542 "Measurement of *Bond Strength of Xypex FCM 80 by Pull-Off"*, exp Services Inc. Burnaby, B.C., Canada TENS-113

Two sets of test specimens were produced; with the first set, 2 layers of FCM-80 was applied directly onto a "dry" substrate, while with the second set the FCM coats were applied to a SSD (i.e. saturated surface dry) substrate. At age 33 days, 50mm diameter / 20mm thick steel "dolly" plates were affixed to all FCM samples utilizing an epoxy adhesive. A Proceq Dyna Z16 pull-off apparatus was used to perform the tensile bond test. Results for the 5 FCM-80 samples applied to a "dry" substrate resulted in an average bond of 0.92 MPa, while the average of the 5 FCM-80 samples applied to a SSD substrate resulted in average bond strength of 0.88 MPa.

EN 1542 "Products and systems for the protection and repair of concrete structures - Test methods - Measurement by Pull-of", McGrath Engineering Services Inc. Burnaby, B.C., Canada TENS-114

Two coats of Xypex Concentrate were applied at 0.8 kg per m^2 with a total cured thickness of 0.9mm to a standard concrete substrate meeting EN 1766 MC (0,40). The coating was applied and cured to the manufacturer's technical specifications and tested at 30 days age for bond strength. The average tensile bond strength of five replicates was 1.23MPa.

EN 1542, "Measurement of *Bond Strength of Xypex Concentrate by Pull-Off"*, *Testing Laboratory No. 1048,* Czech Technical University, Prague, Czech Republic. **TENS-115**

150mm concrete cubes from four different mix designs were treated with a single coat of Xypex Concentrate (@ 0.8 mm to 1 mm thick) to the negative side of the cube as per the required procedures for surface preparation, application and curing. Adhesion testing by bond pull-of from the coated surface was performed; the results reported for the 4 different strength designs were: 1.0, 1.5 1.8 and 2.3MPa. There appears to be a direct correlation in these results with the concrete strength of the parent concrete. The failure typically occurred within the coating itself averaging 90% of the time. Companion samples were also tested for resistance to water pressure according to EN 12390-8 and compared to reference samples.

EN 1542 "*Products and Systems for the Protection and Repair of Concrete Structures – Test Measurement by Pull-off"*. McGrath Engineering Ltd., Vancouver, Canada TENS-116

Two coats of Xypex Concentrate were applied by brush at approximately 0.8kg per m^2 with a total cured thickness of 0.9mm. The average of all test specimens registered 1.23N/mm^2: The minimum result was 1.14N/mm^2; all samples met the "pass" requirements of the average being ≥1.0N/mm^2 with no value of any of the test specimens < 0.7N/mm^2**.**

ASTM D 412 "Evaluation of FCM-80 re Tensile Strength and Elongation Properties", Advanced Plastic & Material Testing, Inc. Ithaca, NY, USA TENS-117

Six "dumbbell-shaped" samples of FCM-80 measuring 0.25" (6.35mm) with an average thickness of 0.08" (2mm) were prepared and then sent to Advanced Laborites for evaluation of tensile strength and elongation. The tensile strength results averaged 157 psi (1.08MPa) and the elongation at break averaged 94%. Another test compared the FCM-80's performance in Dry and in Wet conditions; they were all 0.35" (8.9mm) width and the thickness varied from 0.07" / 1.8mm (Dry) 0.07" / 1.8mm (Wet). The average of 3 samples of the Dry conditions recorded a tensile strength of 258 psi (1.8MPa) and a 70% elongation at break. The average of the 3 Wet samples recorded an average tensile strength of 81.9 psi (0.56MPa) and a 65% elongation.

DRYING SHRINKAGE

AS 1012.13, *"Determination of Drying Shrinkage of Concrete",* Australia Centre of Construction and Innovation, University of New South Wales, Sydney, Australia SHRK-100

Three different sets of samples (measuring 75 mm x 75 mm x 285 mm) were prepared with a 40 MPa design, Mix 1 with Xypex Admix C-2000 plus the superplasticizer, Mix 2 with no Xypex but with the superplasticizer, and Mix 3 with Xypex Admix C-2000 and no superplasticizer. All samples were tested for Drying Shrinkage, Setting times, Absorption and Voids, and Compressive Strength. All samples were moist cured. Dry shrinkage measurements were taken every 7 days up to 56 days. At 56 days Mix 1 and Mix 2 recorded an average of 360 microstrains, Mix 3 recorded an average 330 microstrains. There is a 9% less amount of microstrains in Mix 3 with only the Xypex Admix, compared to the other two mixes.

*Note: any measurement less than 500 microstrains is considered very good…factors that also affect the amount of dry shrinkage are the type of cement, the water-cement ratio, specimen geometry, source of aggregate, ambient relative humidity, etc..

AS1012.13 "*Dry Shrinkage of 40 MPa Concrete Specimens Containing Admix C-1000 NF",* Australia Centre for Construction Innovation, University of New South Wales, Sydney, Australia SHRK-102

Nine different commercial concrete mixes were evaluated to determine the effect of shrinkage. The various mixes included 3 different blends of Type-GB blended cement (25% fly ash, 38% slag and 60% slag). The mixes were dosed with 0.8% and 1.2% Admix C-1000NF. Shrinkage was recorded after 28 and 56 days of standard drying. In the 25% fly ash mix, the Xypex samples had lower shrinkage than the controls by 20 – 25%. The 38% slag results indicated that shrinkage is reduced by 13 – 19% in the Xypex Admix samples. There was little difference in the Type-GB with 60% slag between controls and Xypex samples.

ASTM C157 *"Measurement of Length Change for Concrete Treated with Xypex Admix C-1000 NF",* Construction and Maintenance Technology Research Center (CONTEC), Sirindhorn International Institute of Technology (SIIT) of Thammasat University, Bangkok, Thailand SHRK-104

The objective of this testing was to determine the total shrinkage and autogenous shrinkage of Admix C-1000 NF (1% dosage rate) treated specimens as compared to controls. The mix design varied utilized both Portland cement and 30% Fly Ash concretes and the w/c ratio of 0.5 or 0.6 was used in these mixes. Two sets of prisms measuring 70 x 70 x 300 mm were cast (one for each mix design – the C 1000 NF specimens were dosed with 1%). The specimens were removed from their molds at 8 hour after casting, sealed in plastic and kept at 25^{o}C and 70% RH during testing. Measurements of specimen's lengths were recorded from 1 day to 62 days using ASTM C157 standard test method for measuring length change. Concrete specimens with a higher w/b ratio showed higher drying shrinkage. Concretes with 1% C-1000 NF have lower drying shrinkage to that of the control untreated concrete with 30% fly ash content; while concrete with no fly ash exhibit similar drying shrinkage for both normal concrete and concrete with 1% C-1000 NF.

AS1012.3 "*Test of Dry Shrinkage for Concrete Treated with Xypex Admix C-1000 NF*", Munn, Chang & Kao – Australian Centre for Construction Innovation, University of New South Wales, Sydney, Australia SHRK-105

Xypex Admix C-1000 NF was evaluated for a number of properties to determine its effect on concrete durability in aggressive environments. Three different 32 MPa mix designs were utilized (GP / Portland cement only; GB / 20% Fly Ash replacement; GB – 38% Slag replacement); the samples included controls and C-1000 NF samples (dosed at 0.8% and 1.2%). The drying shrinkage results for the PC samples showed little difference to that of the FPC control mix. All 4 fly ash samples showed better results to that of the PC samples and the 38% slag concretes. Mix-FA2 and Mix-FA3 had lower drying shrinkage than the control (Mix-FA1) by 12% to 14% at 56 days.

ABRASION RESISTANCE

ASTM D 2240 *"Standard Test Method for Rubber Properties of FCM-80 – Durometer Hardness (Shore A)", Levelton Consultants* Ltd., Richmond, B.C., Canada ABRA-103

FCM-80 samples were prepared by applying 2 coats at a total thickness of 6.22mm to a polyethylene sheet. The 10 replicate samples were dry cured for 120 prior to initiating the test procedure; A Durometer was used to measure hardness; the average Shore A hardness was 58.

FIRE RESISTANCE

AS 1530.4 "*Fire Resistance Testing of Elements of Building Construction*", CSIRO, Australia **FIRE-100**

Two different mix designs were utilized to produce four separate concrete panels; each design included a control panel and an Admix treated panel from which cores were extracted to perform durability testing following exposure to hydrocarbon fire testing. Randomly selected cores were subsequently visually examined to determine what if any deterioration was evident. There was negligible visual difference noted in any of the samples tested from either mix design. Following this, the cores were tested to determine the effect on: compressive strength, water permeability and chloride diffusion. The residual compressive strength of the Xypex Admix treated concrete specimens was shown to be slightly higher than that of the control specimens. Water permeability testing of concrete panel No. 8 illustrated that the Xypex treated sample resulted in 30% less permeability than that the control panel No. 6 of the same mix design (360kg/m^3). Chloride penetration testing also of concrete panel No. 8 illustrated that the Xypex treated sample had significantly lowered the chloride penetration by 80% when compared to control sample from the same mix design.

APPROVALS RE POTABLE WATER & PUBLIC HEALTH & FOR LOCAL OR REGIONAL BUILDING CODE APPROVAL

XYPEX products have been tested for toxicity and / or its suitability in contact with potable water by numerous independent agencies throughout the world. In each test, Xypex has been shown to be non-toxic and to contain no ingredients or constituents that are harmful to potable water. Approvals for Xypex use have been obtained from the following Government and / or Independent Agencies. Xypex also has been tested to local, regional or national building code standards.

NSF 61 *"Drinking Water System Component - Health Effects",* NSF, Ann Arbor, Michigan **APPR-100**

Water Bylaws Scheme - UK Water Approval, Testing by Bostock, Hill & Rigby, Birmingham, England **APPR-101**

Drinking Water Inspectorate - DWI - (UK Authority responsible for product approval re potable water), London, England **APPR-201**

Singapore Institute of Standards and Industrial Research **APPR-102**

Japan Ministry of Public Welfare, Tokyo, Japan **APPR-103**

Japan Food Research Laboratories (Water Quality Test according to Tap Water Act) Tokyo, Japan **APPR-203**

Health Department & Water Authority of Western Australia Perth, Australia **APPR-104**

Australian Water Quality Centre (Authority for approval of all products in contact with potable water) Bolivar, South Australia **APPR-204**

State Health Institute & Center for Drinking Water, State Health Institute, Prague, Czech Republic **APPR-105**

National Research Center, Water Pollution Control Lab, Cairo, Egypt **APPR-006**

Ministry of Health, Public Health Service, Jerusalem, Israel **APPR-007**

Federal Department of Health, Division of Chemicals, Berne, Switzerland **APPR-008**

National Institute of Occupational Health, Register of Substances and Materials, Copenhagen, Denmark **APPR-009**

Mairie De Paris, Research Center for the Control of Water, Paris, France **APPR-010**

WHMIS (Workplace Hazardous Materials Information System), Ottawa, Canada **APPR-011**

SBCCI Public Safety Testing, Standard Building Code, Birmingham, USA **APPR-012**

Ministry of Health (Zdravotnictva), Bratislava, Slovak Republic **APPR-013**

DIBT, Building Code Authority, (covers use of Admix C-1000 NF)**,** Berlin, Germany **APPR-014**

CEBTP, Cahier Des Charges, Paris, France **APPR-015**

BBA, British Board of Agrément, (covers building regulation for Admix C-1000 NF)**,** London, United Kingdom **APPR-016**

Certificate of Approval, Building Code Authority, (for Admix C-1000 NF)**,** Goteborg, Sweden **APPR-017**

CE Certification for Admix C-500, C-1000 & C-2000, Concentrate, Modified, Patch'n Plug, Megamix I & Xycrylic Admix and Megamix II.