XYPEX
CHEMICAL CORPORATION

FACSIMILE TRANSMISSION

August 30, 1995

To: Concrete Waterproofing Manufacturing Pty., Ltd.,

Attn: Mr. Neil Jones

Re: Reduction of Carbonation

Dear Neil,

Dave Ross is currently away from the office "on vacation".

We can confirm that Xypex has been proven to significantly reduce the effects of carbonation of concrete. Please refer to copy of "Japan Atomic Energy Research Institute's Test Report No. JAERI - M 89-211", page 8 (copy attached). You will note that they compared a reference mortar sample to that of the Xypex treated cement mortar, measuring "carbonated thickness" following a 100 day exposure to 5% concentration of CO_2 gas. The results indicate penetration on the reference sample was much greater at 14.4 mm to that of the Xypex treated sample at 8.4 mm.

Best Regards,

XYPEX CHEMICAL CORPORATION

Vic Barber
Operations Manager

Manufacturers & Distributors throughout the World

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JAERI - M
89-211

セメントモルタル中の^{137}Csの拡散に関する研究

1989年12月

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日本原子力研究所
Japan Atomic Energy Research Institute

Studies on Diffusion of ^{137}Cs in Cement Mortar

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Penetration experiment of ^{137}Cs into the impermeable cement mortar which has been treated by the impermeable reagent (XYPEX reagent) was carried out in order to advance the performance of engineered barrier for Low Level Radioactive Waste.

The result showed that the radioactive concentration at deeper region in the impermeable cement mortar specimen was decreased about 1 order of magnitude below that in the untreated specimen. Diffusion coefficient calculated from the radioactive concentration of ^{137}Cs in the cement mortar specimen was 9.1×10^{-5} cm^2/day for untreated cement mortar specimen and 4.0×10^{-5} cm^2/day for the impermeable cement mortar specimen, respectively.

Treatment of cement mortar by the impermeable reagent was found to be effective to reduce the value of appearent diffusion coefficient for ^{137}Cs in the cement mortar.

Keywords: Diffusion, ^{137}Cs, Impermeable Cement Mortar, Impermeable Reagent, Diffusion Coefficient, Engineered Barrier, LLRW

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* JAPAN XYPEX Co. Ltd.

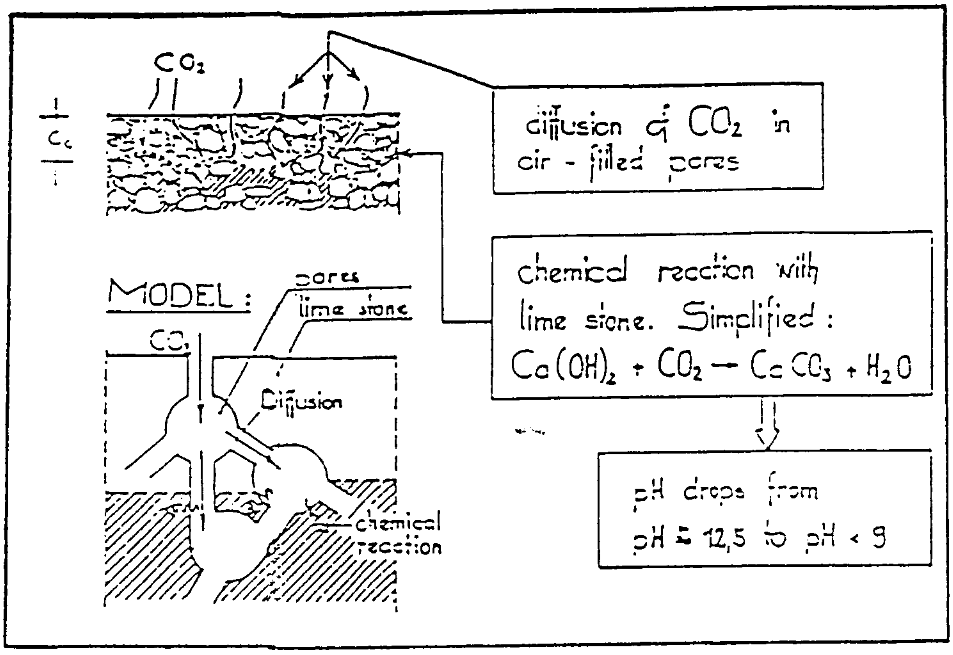
Table 1 Chemical composition of Portland cement, Impermeable reagent and Tyoura sand.

Chemical composition	Portland cement (wt%)	Impermeable reagent (wt%)	Toyoura sand (wt%)
CaO	63.8	30.9	88.16
SiO_2	22.1	20.3	0.17
Al_2O_3	5.0	1.7	3.4
Fe_2O_3	3.0	4.3	0.63
MgO	1.6	19.4	2.77
Na_2O	0.35	5.0	0.13
K_2O	0.54	0.15	D.L.
TiO_2	0.30	0.18	0.76
SO_3	2.0	1.0	2.14
P_2O_5	0.11	0.20	--
MnO	0.13	0.06	--
TOTAL	98.93	83.19	98.16

D.L. ; detection limit

Table 2 Physicochemical characteristics of cement mortar and impermeable cement mortar.

Physicochemical characteristics	Cement mortar	Impermeable cement mortar	Analytical method
Specific gravity (g/cm^3)	1.989	2.028	JIS-A-1202-1978
Tri-axial compressive strength (kg/cm^2)	300	344	JIS-A-1108
Water permeation distance (mm)	84	4	DIN-1048 Permeability test (Input method , Contact time :4day)
Corrosion ratio	0.210	0.117	Resistance to acid attak test (5%H_2SO_4 solu., Contact time:100day)
* Carbonated thickness (mm)	14.4	8.4	(CO_2 gas conc. 5% , Temp. 30℃ , Contact time:100day)
Drying shrinkage ratio	1.2×10^{-3}	1.0×10^{-3}	JIS-A-1129 (Measurement of length change , Contact time:100day)



2.2 Carbonation of Concrete

2.2.1 Concrete is a porous material and the CO_2 in the air may therefore penetrate via the pores to the interior of the concrete. Therefore, a chemical reaction will take place with the calcium-hydroxide. In very simplified terms, the chemical reaction may be described as follows:

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$$

As it is mainly the $Ca(OH)_2$ that causes the high pH-value of the concrete to develop and be maintained, the pH-value will drop below 9 after the concrete has been totally carbonated.

2.2.2 As already mentioned, the CO_2 penetrates from the surface to the interior of the concrete. Consequently, the carbonation starts from the concrete surface and penetrates slowly to the interior of the concrete. The speed-determining process is the diffusion of CO_2 into concrete.

2.2.3 Roughly simplified, the rate of carbonation (ie the increase of carbonation depth with time) follows a square-root-time law.

2.2.4 The decisive parameter of concrete quality is the permeability which, for a given environment, depends on the pore structure.

2.2.5 Diffusion of CO_2 is only possible in air filled pores. For this reason, totally water-saturated concrete will not carbonate.

XYPEX
CHEMICAL CORPORATION

FACSIMILE TRANSMISSION

July 9, 1996

To: Mullins & Associates

Attn: Dr. Peter Mullins

Re: Carbonation Resistance of Xypex Modified Concentrate

Dear Dr. Mullins,

With reference to your fax of July 8, 1996 I have enclosed information regarding testing done by the Japan Atomic Energy Research Institute on carbon dioxide gas and Xypex treated concrete. Although Xypex is a breathable material it restricted gas diffusion by 42% compared to the reference concrete.

Regarding the statements made about Xypex by the consulting engineer they are all true. Because the Xypex coating is alkaline it will restore the pH at and near the surface of carbonated concrete, due to the alkalinity present in the cement portion of the coating. Over time and in the presence of carbon dioxide gas I would also expect the pH of the coating to decline. As expressed in the statement made by the consulting engineer the main advantage of the Xypex treatment is its ability to penetrate concrete using water as a migrating medium and by preventing further moisture ingression will help to control further corrosion of the reinforcing steel.

If the sole problem is strictly carbonation of the concrete and no other elements of corrosion are present (ie water) then you can either leave the concrete as is or put a protective, non-breathing coating over top of the surface to stop further gas diffusion.

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July 9, 1996
Mullins & Associates
Dr. Peter Mullins

In the event that moisture is already present or it can be assumed that moisture ingress can take place then the use of Xypex could be contemplated. In a situation such as this and with the knowledge that carbonation will continue to occur then the Xypex could be overcoated with a protective material.

This system would have the benefit of both stopping further carbonation while at the same time preserving the reinforcing steel from the destructive effects of corrosion.

Sincerely,

XYPEX CHEMICAL CORPORATION

Dave Ross
Technical Services Manager