XYPEX CRYSTALLINE TECHNOLOGY

Sustainable Concrete Construction

Agenda

Xypex Crystalline Technology Contributes To Sustainable Construction

Durability
1

Service Life
2

Carbon Footprint
3

Introduction

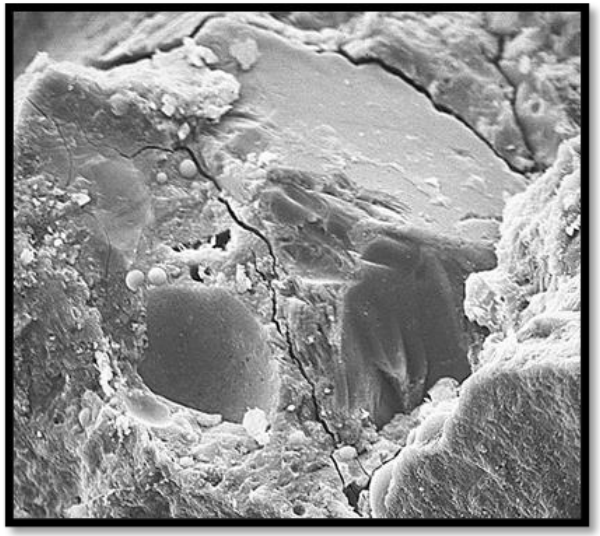
Concrete Cracking

Cracks = Direct route for water ingress

- Ingress of water into concrete brings chlorides or sulfates.

- Ingress of water into concrete is the most common cause of concrete deterioration.

- Xypex crystalline can self-heal cracks up to 0.5mm.



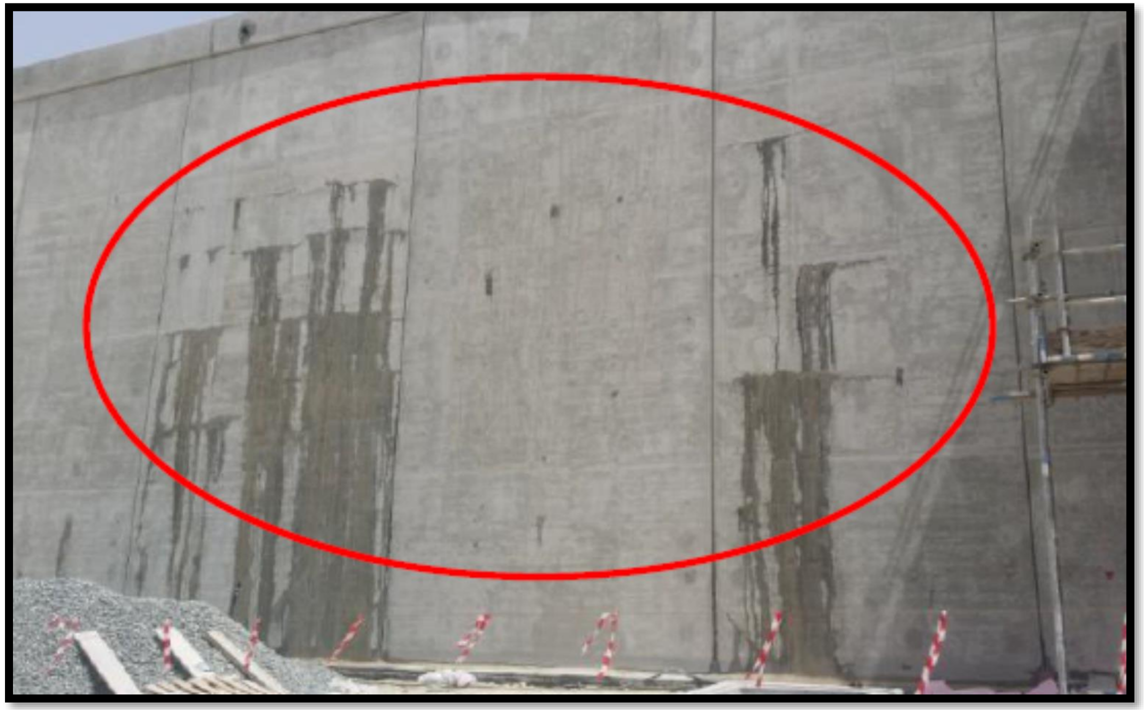
Xypex Crack Healing

Ras Abbu Fontas Water Reservoir, Qatar

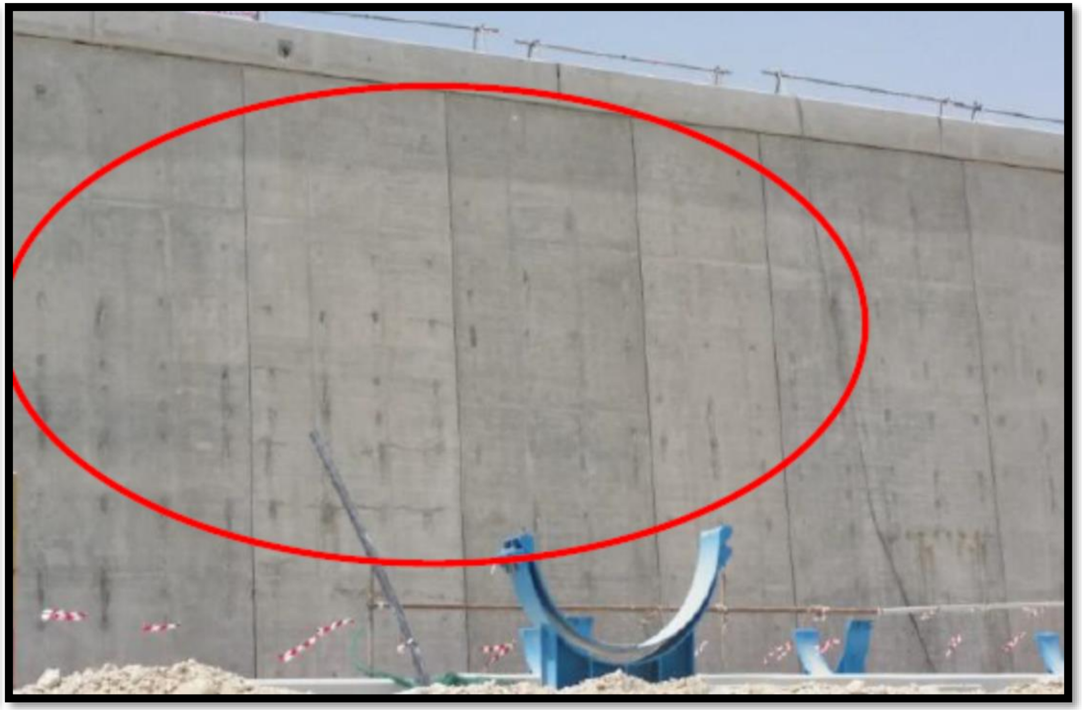
- Two potable water tanks
- 30,000 m^2 footprints
- 56,000 m^2 treated with 2 coats Xypex Concentrate
- 24,000 tie-holes treated with Patch‘n Plug/Dry-Pac

Xypex Crack Healing

Ras Abbu Fontas Water Reservoir, Qatar



24th May 2017



2nd June 2017

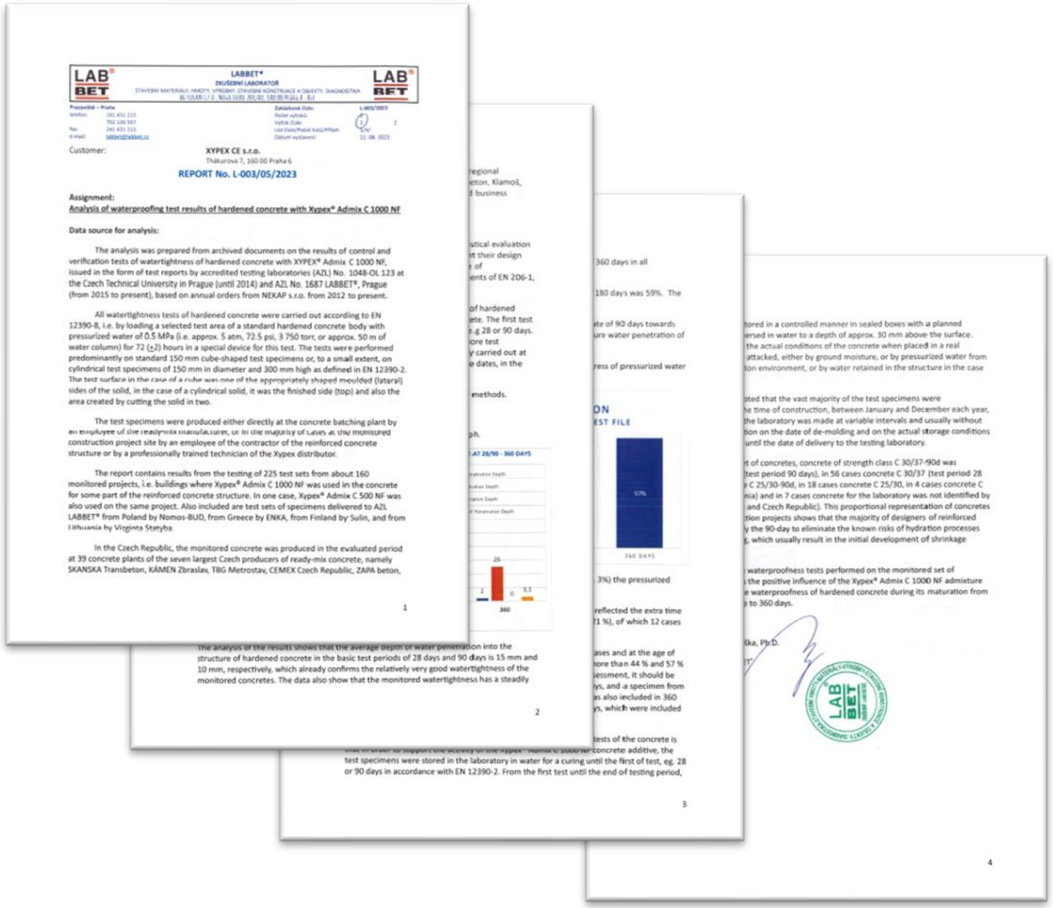
Impact on Durability

Study of Xypex Permeability Reduction

What was measured?

Key Figures

- Study conducted from 2012 to 2023
- 225 sets of concrete samples
- 160 projects
- 5 Countries



REAL-WORLD PERFORMANCE

Compatibility with Cement & SCMs

Decades of Efficacy with Various Cements and SCMs

- 11-year study showing efficacy over 1 year on 225 sets
- Slag content up to 80%

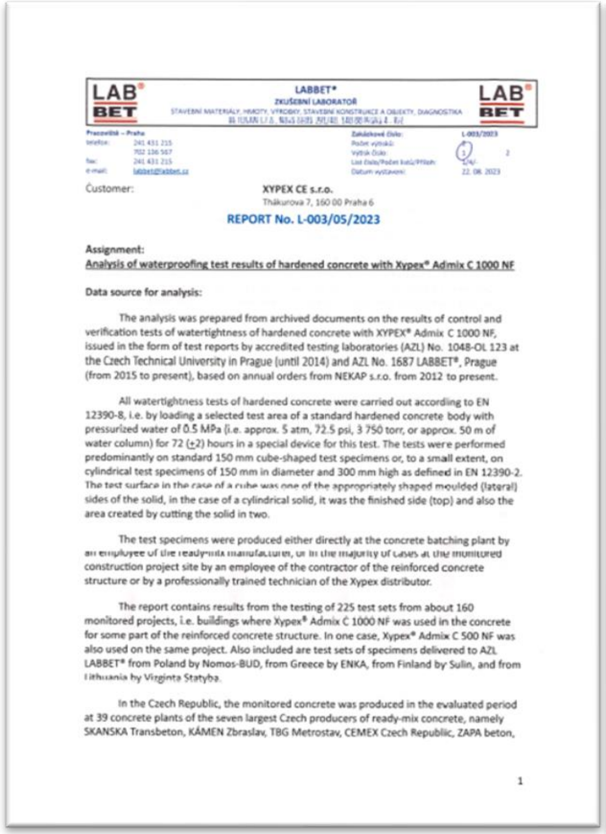
  (CEM III/B – GGBFS)
- Limestone content up to 35% (CEM II/B – LL)

Main types	Notation of the 27 products (types of common cement)		Composition (percentage by mass[a]) – Main constituents: Clinker	Blast-furnace slag	Silica fume	Pozzolana: natural	Pozzolana: natural calcined	Fly ash: siliceous	Fly ash: calcareous	Burnt shale	Limestone	Limestone	Minor additional constituent
			K	S	D[b]	P	Q	V	W	T	L	LL	
CEM I	Portland cement	CEM I	95-100	–	–	–	–	–	–	–	–	–	0-5
CEM II	Portland-slag cement	CEM II/A-S	80-94	6-20	–	–	–	–	–	–	–	–	0-5
		CEM II/B-S	65-79	21-35	–	–	–	–	–	–	–	–	0-5
	Portland-silica fume cement	CEM II/A-D	90-94	–	6-10	–	–	–	–	–	–	–	0-5
	Portland-pozzolana cement	CEM II/A-P	80-94	–	–	6-20	–	–	–	–	–	–	0-5
		CEM II/B-P	65-79	–	–	21-35	–	–	–	–	–	–	0-5
		CEM II/A-Q	80-94	–	–	–	6-20	–	–	–	–	–	0-5
		CEM II/B-Q	65-79	–	–	–	21-35	–	–	–	–	–	0-5
	Portland-fly ash cement	CEM II/A-V	80-94	–	–	–	–	6-20	–	–	–	–	0-5
		CEM II/B-V	65-79	–	–	–	–	21-35	–	–	–	–	0-5
		CEM II/A-W	80-94	–	–	–	–	–	6-20	–	–	–	0-5
		CEM II/B-W	65-79	–	–	–	–	–	21-35	–	–	–	0-5
	Portland-burnt shale cement	CEM II/A-T	80-94	–	–	–	–	–	–	6-20	–	–	0-5
		CEM II/B-T	65-79	–	–	–	–	–	–	21-35	–	–	0-5
	Portland-limestone cement	CEM II/A-L	80-94	–	–	–	–	–	–	–	6-20	–	0-5
		CEM II/B-L	65-79	–	–	–	–	–	–	–	21-35	–	0-5
		CEM II/A-LL	80-94	–	–	–	–	–	–	–	–	6-20	0-5
		CEM II/B-LL	65-79	–	–	–	–	–	–	–	–	21-35	0-5
	Portland-composite cement[c]	CEM II/A-M	80-88	← 12-20 →									0-5
		CEM II/B-M	65-79	← 21-35 →									
CEM III	Blast furnace cement	CEM III/A	35-64	36-65	–	–	–	–	–	–	–	–	0-5
		CEM III/B	20-34	66-80	–	–	–	–	–	–	–	–	0-5
		CEM III/C	5-19	81-95	–	–	–	–	–	–	–	–	0-5
CEM IV	Pozzolanic cement[c]	CEM IV/A	65-89	–	<— 11-35 —>					–	–	–	0-5
		CEM IV/B	45-64	–	<— 36-55 —>					–	–	–	0-5
CEM V	Composite cement[c]	CEM V/A	40-64	18-30	–	<— 18-30 —>			–	–	–	–	0-5
		CEM V/B	20-38	31-49	–	<— 31-49 —>			–	–	–	–	0-5

Study of Xypex Permeability Reduction

Basis of the Study

LABBET Testing Laboratory



LAB BET | LABBET® ZKUŠEBNÍ LABORATOŘ STAVEBNÍ MATERIÁLY, HMOTY, VÝROBKY, STAVEBNÍ KONSTRUKCE A OBJEKTY, DIAGNOSTIKA | LAB BET

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Zakázkové číslo: L-003/2023
Počet výtisků:
Výtisk číslo: 1 2
List číslo/Počet listů/Příloh: 1/4/-
Datum vystavení: 22. 08. 2023

Customer: XYPEX CE s.r.o.
Thákurova 7, 160 00 Praha 6

REPORT No. L-003/05/2023

Assignment:
Analysis of waterproofing test results of hardened concrete with Xypex® Admix C 1000 NF

Data source for analysis:

The analysis was prepared from archived documents on the results of control and verification tests of watertightness of hardened concrete with XYPEX® Admix C 1000 NF, issued in the form of test reports by accredited testing laboratories (AZL) No. 1048-OL 123 at the Czech Technical University in Prague (until 2014) and AZL No. 1687 LABBET®, Prague (from 2015 to present), based on annual orders from NEKAP s.r.o. from 2012 to present.

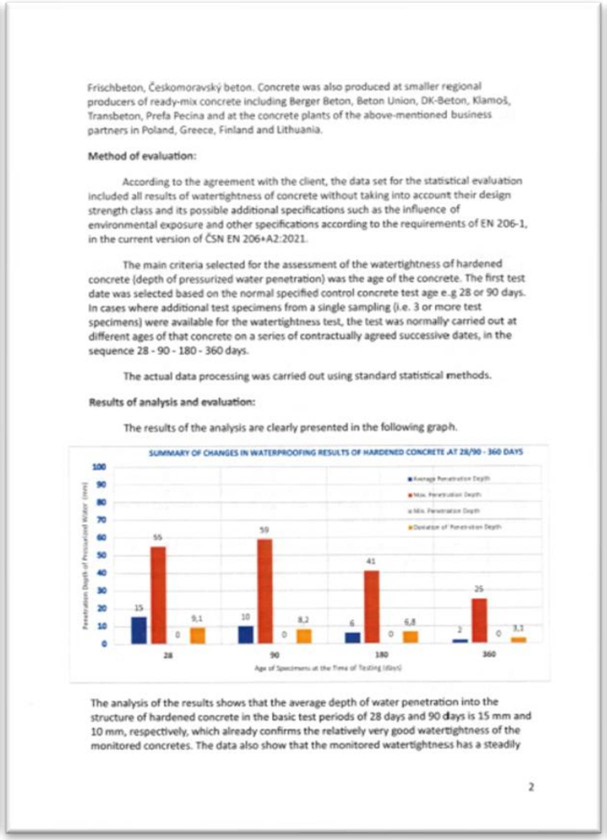
All watertightness tests of hardened concrete were carried out according to EN 12390-8, i.e. by loading a selected test area of a standard hardened concrete body with pressurized water of 0.5 MPa (i.e. approx. 5 atm, 72.5 psi, 3 750 torr, or approx. 50 m of water column) for 72 (±2) hours in a special device for this test. The tests were performed predominantly on standard 150 mm cube-shaped test specimens or, to a small extent, on cylindrical test specimens of 150 mm in diameter and 300 mm high as defined in EN 12390-2. The test surface in the case of a cube was one of the appropriately shaped moulded (lateral) sides of the solid, in the case of a cylindrical solid, it was the finished side (top) and also the area created by cutting the solid in two.

The test specimens were produced either directly at the concrete batching plant by an employee of the ready-mix manufacturer, or in the majority of cases at the monitored construction project site by an employee of the contractor of the reinforced concrete structure or by a professionally trained technician of the Xypex distributor.

The report contains results from the testing of 225 test sets from about 160 monitored projects, i.e. buildings where Xypex® Admix C 1000 NF was used in the concrete for some part of the reinforced concrete structure. In one case, Xypex® Admix C 500 NF was also used on the same project. Also included are test sets of specimens delivered to AZL LABBET® from Poland by Nomos-BUD, from Greece by ENKA, from Finland by Sulin, and from Lithuania by Virginta Statyba.

In the Czech Republic, the monitored concrete was produced in the evaluated period at 39 concrete plants of the seven largest Czech producers of ready-mix concrete, namely SKANSKA Transbeton, KÁMEN Zbraslav, TBG Metrostav, CEMEX Czech Republic, ZAPA beton,

1



Frischbeton, Českomoravský beton. Concrete was also produced at smaller regional producers of ready-mix concrete including Berger Beton, Beton Union, DK-Beton, Klamoš, Transbeton, Prefa Pecina and at the concrete plants of the above-mentioned business partners in Poland, Greece, Finland and Lithuania.

Method of evaluation:

According to the agreement with the client, the data set for the statistical evaluation included all results of watertightness of concrete without taking into account their design strength class and its possible additional specifications such as the influence of environmental exposure and other specifications according to the requirements of EN 206-1, in the current version of ČSN EN 206+A2:2021.

The main criteria selected for the assessment of the watertightness of hardened concrete (depth of pressurized water penetration) was the age of the concrete. The first test date was selected based on the normal specified control concrete test age e.g 28 or 90 days. In cases where additional test specimens from a single sampling (i.e. 3 or more test specimens) were available for the watertightness test, the test was normally carried out at different ages of that concrete on a series of contractually agreed successive dates, in the sequence 28 - 90 - 180 - 360 days.

The actual data processing was carried out using standard statistical methods.

Results of analysis and evaluation:

The results of the analysis are clearly presented in the following graph.

The analysis of the results shows that the average depth of water penetration into the structure of hardened concrete in the basic test periods of 28 days and 90 days is 15 mm and 10 mm, respectively, which already confirms the relatively very good watertightness of the monitored concretes. The data also show that the monitored watertightness has a steadily

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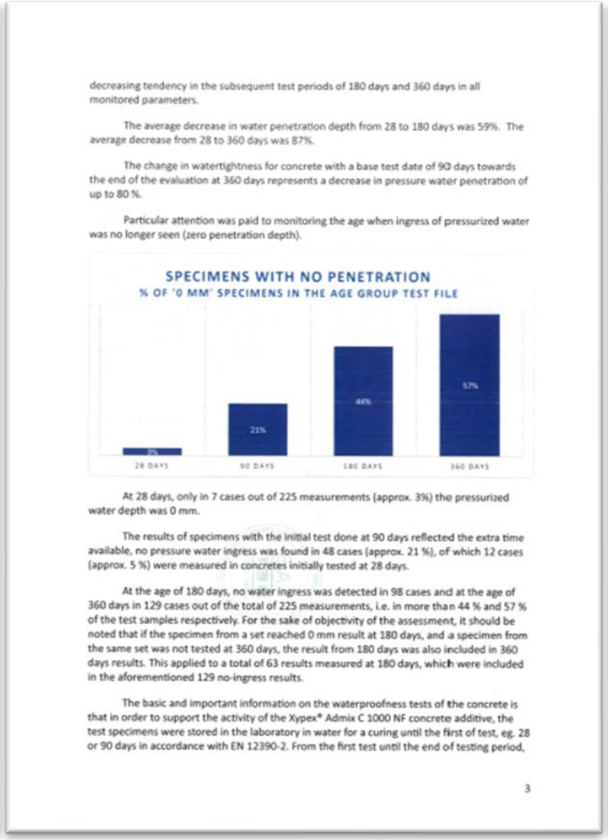


decreasing tendency in the subsequent test periods of 180 days and 360 days in all monitored parameters.

The average decrease in water penetration depth from 28 to 180 days was 59%. The average decrease from 28 to 360 days was 87%.

The change in watertightness for concrete with a base test date of 90 days towards the end of the evaluation at 360 days represents a decrease in pressure water penetration of up to 80 %.

Particular attention was paid to monitoring the age when ingress of pressurized water was no longer seen (zero penetration depth).

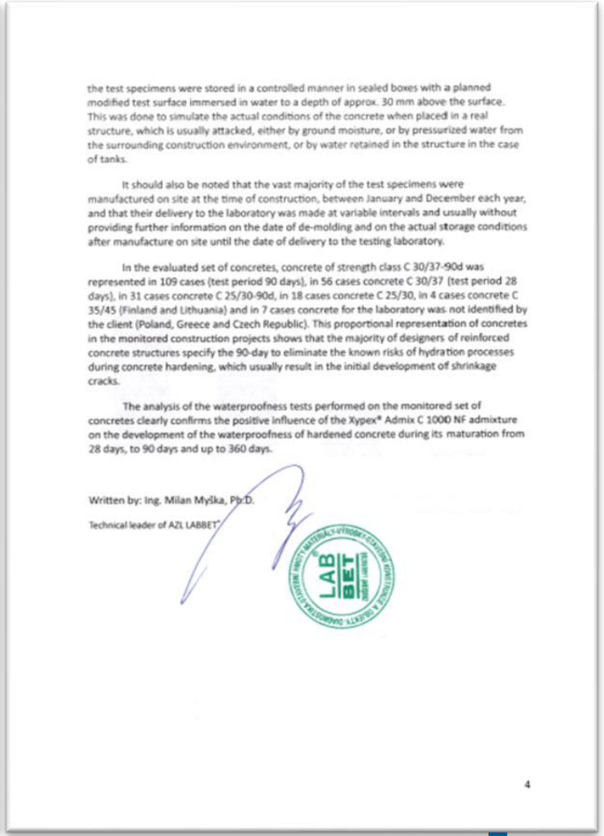
At 28 days, only in 7 cases out of 225 measurements (approx. 3%) the pressurized water depth was 0 mm.

The results of specimens with the initial test done at 90 days reflected the extra time available, no pressure water ingress was found in 48 cases (approx. 21 %), of which 12 cases (approx. 5 %) were measured in concretes initially tested at 28 days.

At the age of 180 days, no water ingress was detected in 98 cases and at the age of 360 days in 129 cases out of the total of 225 measurements, i.e. in more than 44 % and 57 % of the test samples respectively. For the sake of objectivity of the assessment, it should be noted that if the specimen from a set reached 0 mm result at 180 days, and a specimen from the same set was not tested at 360 days, the result from 180 days was also included in 360 days results. This applied to a total of 63 results measured at 180 days, which were included in the aforementioned 129 no-ingress results.

The basic and important information on the waterproofness tests of the concrete is that in order to support the activity of the Xypex® Admix C 1000 NF concrete additive, the test specimens were stored in the laboratory in water for a curing until the first of test, eg. 28 or 90 days in accordance with EN 12390-2. From the first test until the end of testing period,

3



the test specimens were stored in a controlled manner in sealed boxes with a planned modified test surface immersed in water to a depth of approx. 30 mm above the surface. This was done to simulate the actual conditions of the concrete when placed in a real structure, which is usually attacked, either by ground moisture, or by pressurized water from the surrounding construction environment, or by water retained in the structure in the case of tanks.

It should also be noted that the vast majority of the test specimens were manufactured on site at the time of construction, between January and December each year, and that their delivery to the laboratory was made at variable intervals and usually without providing further information on the date of de-molding and on the actual storage conditions after manufacture on site until the date of delivery to the testing laboratory.

In the evaluated set of concretes, concrete of strength class C 30/37-90d was represented in 109 cases (test period 90 days), in 56 cases concrete C 30/37 (test period 28 days), in 31 cases concrete C 25/30-90d, in 18 cases concrete C 25/30, in 4 cases concrete C 35/45 (Finland and Lithuania) and in 7 cases concrete for the laboratory was not identified by the client (Poland, Greece and Czech Republic). This proportional representation of concretes in the monitored construction projects shows that the majority of designers of reinforced concrete structures specify the 90-day to eliminate the known risks of hydration processes during concrete hardening, which usually result in the initial development of shrinkage cracks.

The analysis of the waterproofness tests performed on the monitored set of concretes clearly confirms the positive influence of the Xypex® Admix C 1000 NF admixture on the development of the waterproofness of hardened concrete during its maturation from 28 days, to 90 days and up to 360 days.

Written by: Ing. Milan Myška, Ph.D.

Technical leader of AZL LABBET®

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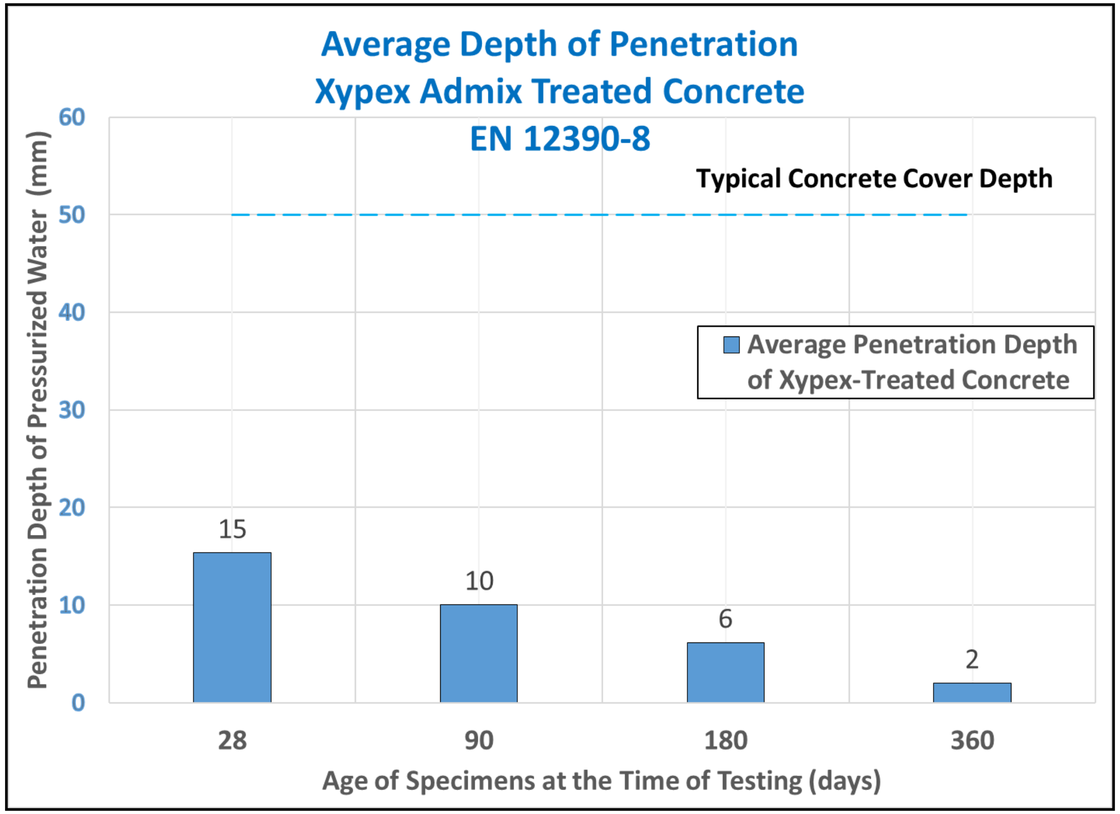
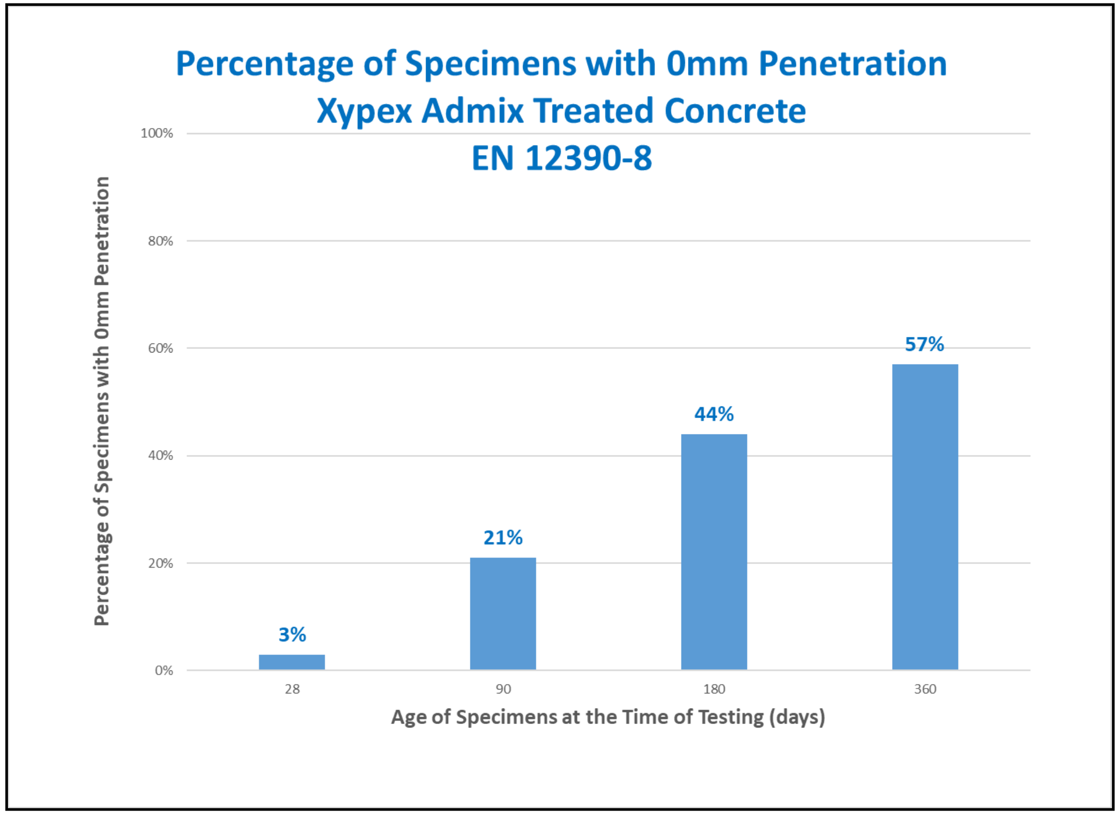
Study of Xypex Permeability Reduction

What does the Study Show?



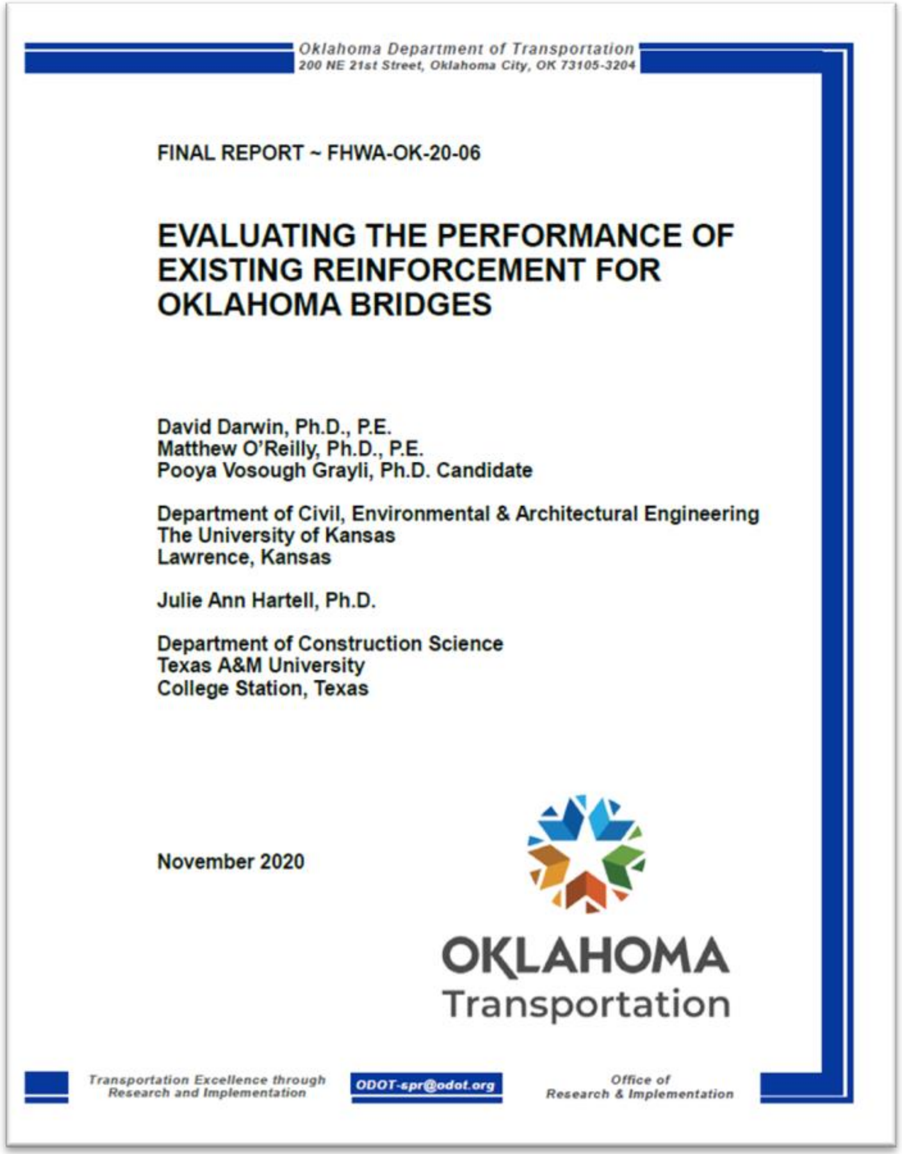


Influence of Crack Healing on Durability of Concrete

XYPEX®

Oklahoma Department of Transportation Study

- Evaluated the Impact of adding Xypex to bridge deck concrete
- 96-week study
- Very aggressive chloride environments on uncracked and cracked Concrete



Oklahoma Department of Transportation
200 NE 21st Street, Oklahoma City, OK 73105-3204

FINAL REPORT ~ FHWA-OK-20-06

EVALUATING THE PERFORMANCE OF EXISTING REINFORCEMENT FOR OKLAHOMA BRIDGES

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November 2020

OKLAHOMA Transportation

Transportation Excellence through Research and Implementation

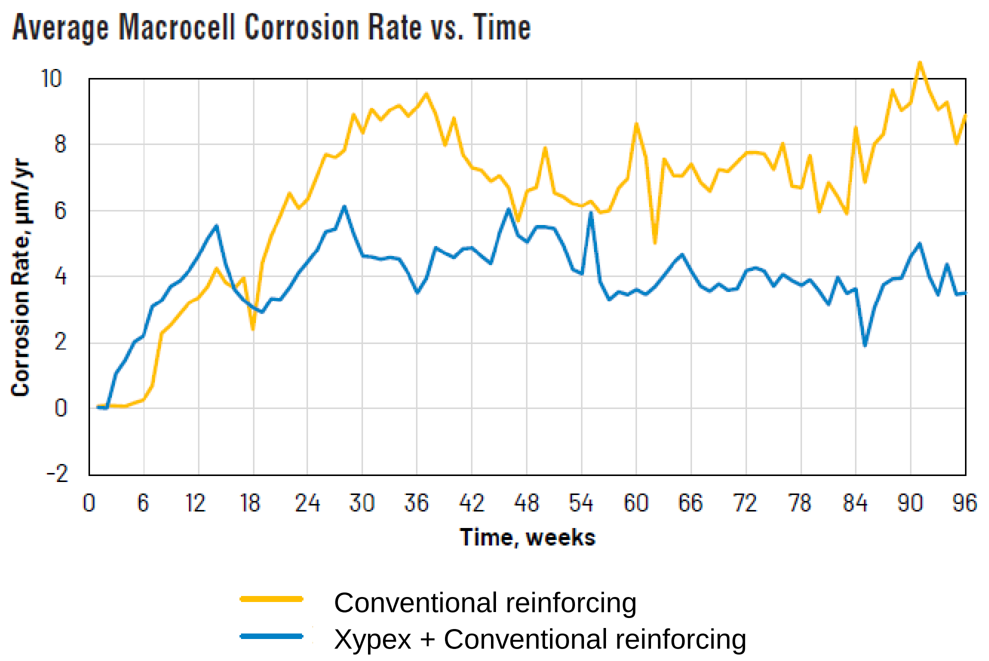
ODOT-spr@odot.org

Office of Research & Implementation

Influence of Crack Healing on Durability of Concrete

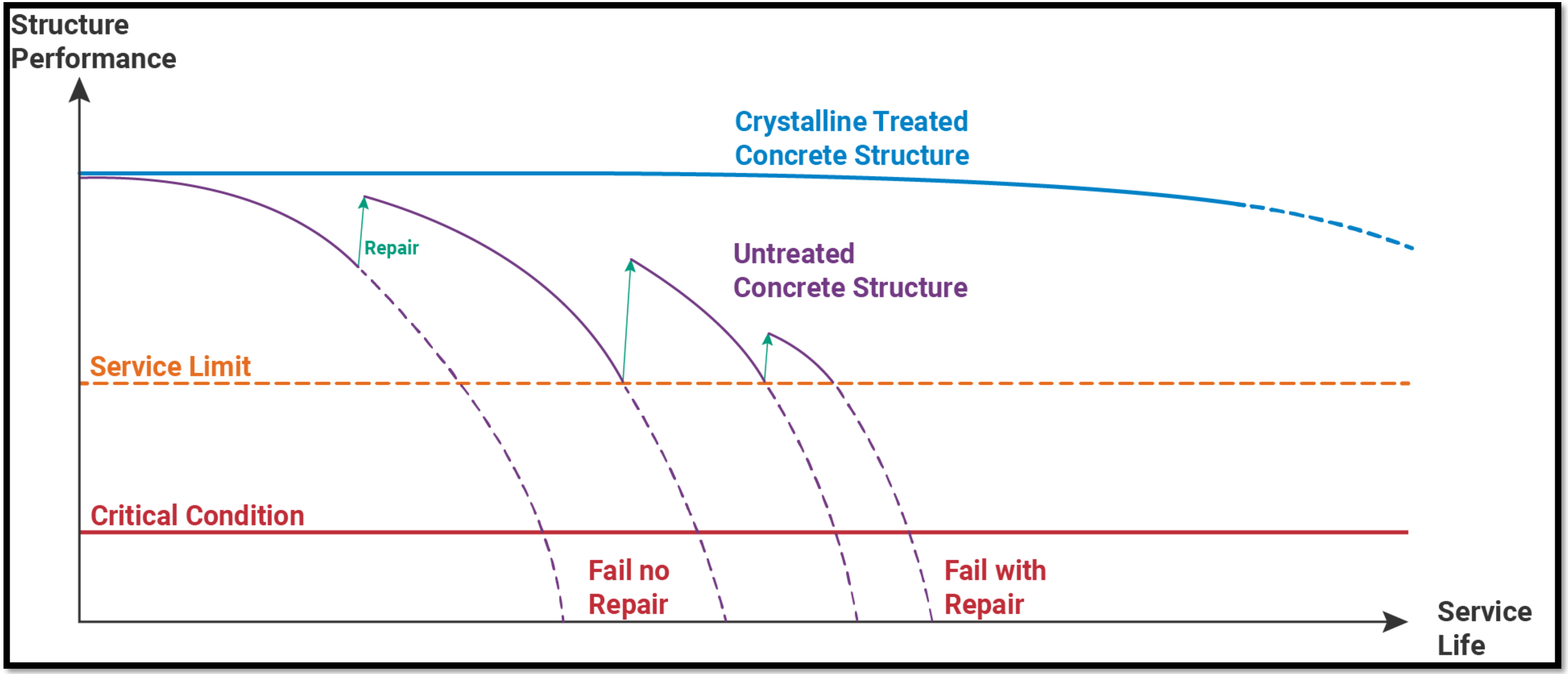
Oklahoma Department of Transportation Study Findings:

- Xypex doubled the time to first repair
- Xypex reduced the amount of corrosion
  - by 40-44% in uncracked concrete
  - by 70% in cracked concrete



Impact on Service Life

Extended Service Life



Influence of Crack Healing on Durability of Concrete

Oklahoma Department of Transportation Study Findings:

Cost of Ownership – 100-Year Design – 8-Inch Deck, 2.5-Inch Cover

	Initial Cost, $/yd^2	Time to Repair, Years					Repair Cost, $/yd^2	Total Present Cost, $/yd^2
		1	2	3	4	5		
Conventional Reinforcing A	$175.95	22.0	44.1	66.1	88.2		$499.13	$929
Conventional Reinforcing B	$175.95	19.2	38.4	57.7	76.9	96.1	$499.13	$1,093
Conventional Reinforcing C	$175.95	26.1	52.1	78.2			$499.13	$758
Xypex + Conventional Reinforcing A	$180.26	32.4	64.7	97.1			$503.44	$659
Xypex + Conventional Reinforcing B	$180.26	27.6	55.1	82.7			$503.44	$739
Xypex + Conventional Reinforcing C	$180.26	39.8	79.6				$503.44	$513

Xypex Protects Concrete from Corrosion

Cronulla Wharf, Australia

Xypex Case Study

- Built in 1994
- 40 – 45 mm concrete cover
- Condition Assessment Conducted in
  - 1998 (4 years)
  - 2013 (19 years)

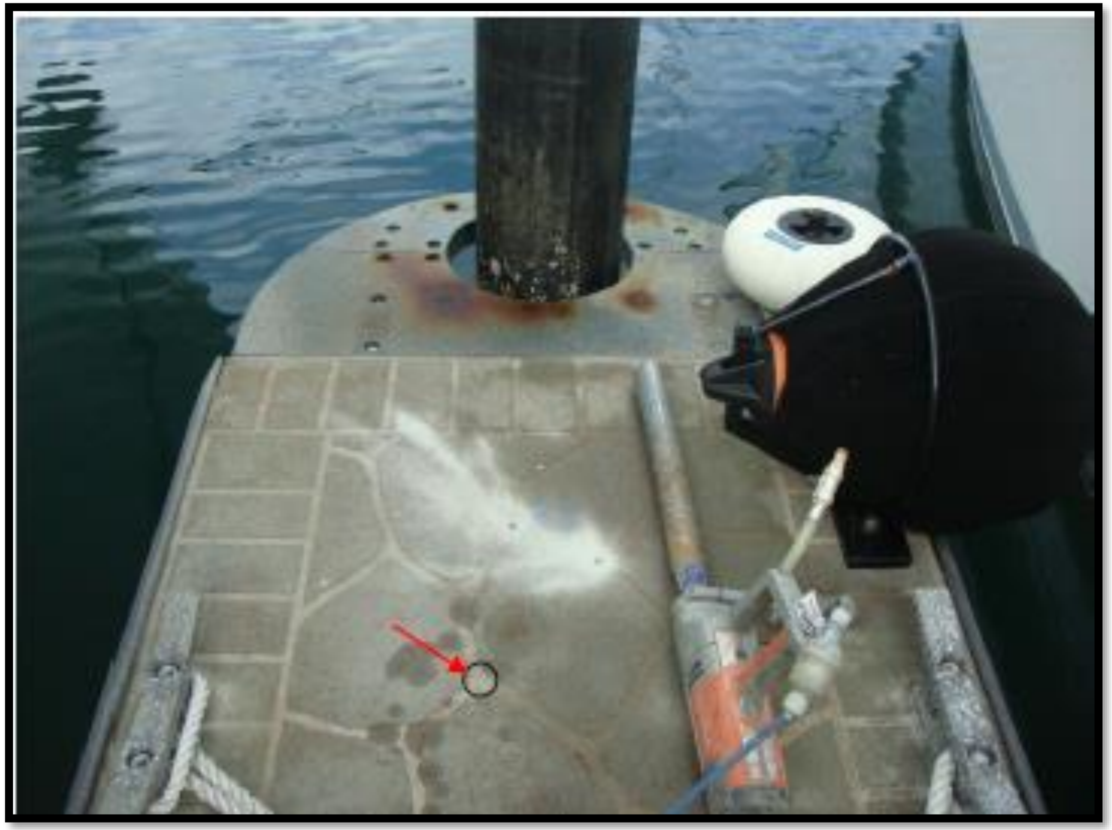
Xypex Protects Concrete from Corrosion

Cronulla Wharf

Design Service Life = 50 years

Predicted Time to 0.4% Cl^- content (40mm cover) = 129 years

Predicted Time to 0.4% Cl^- content (45mm cover) = 164 years

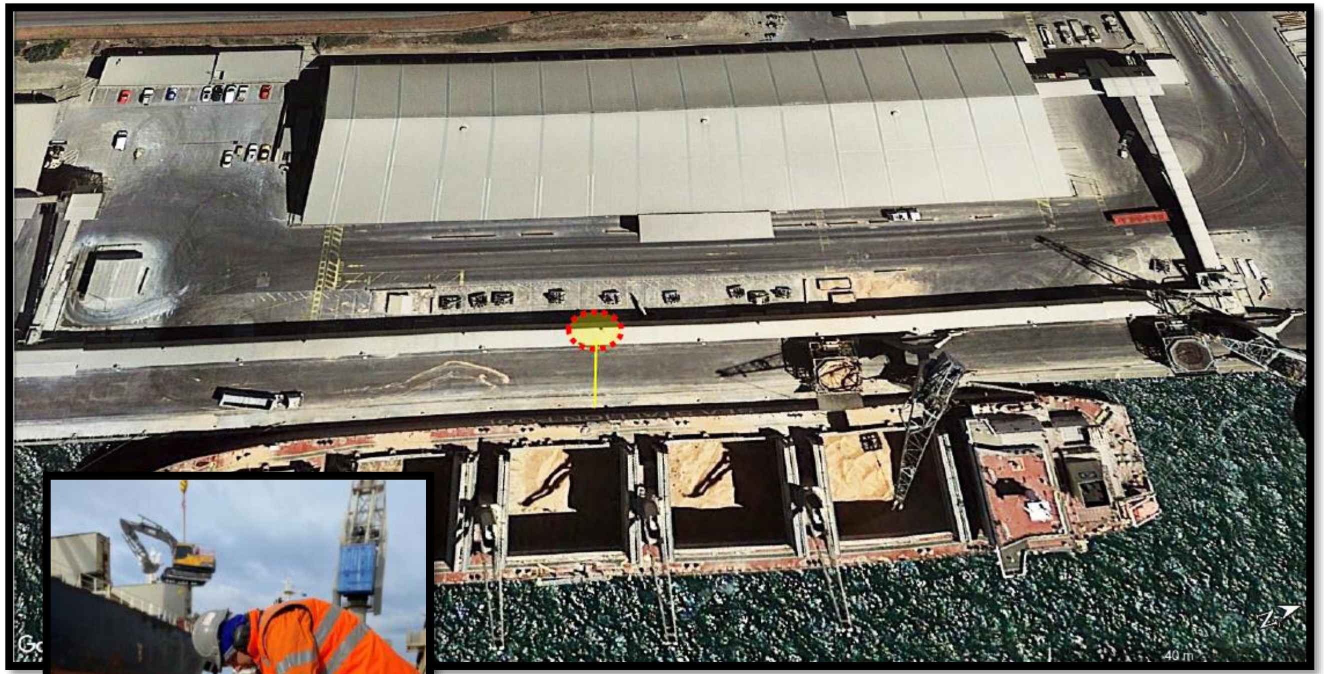


Xypex Protects Concrete from Corrosion

Lascelles Wharf in Port of Geelong, Australia

Xypex Case Study

- 400 kg (881lbs) GP Cement, 40 Mpa (5800 psi), 0.45 W/C
- Minimum 51mm concrete cover
- Condition Assessment Conducted in
  - 2021 (26 years)



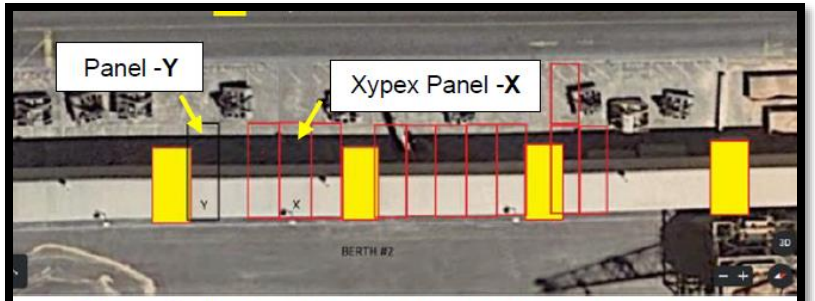


Figure 2: A view showing the location of two panels

Xypex Protects Concrete from Corrosion

Lascelles Wharf in Port of Geelong, Australia

Xypex Case Study

Predicted Time to 0.4% Cl^- content = 187 years (51mm cover)

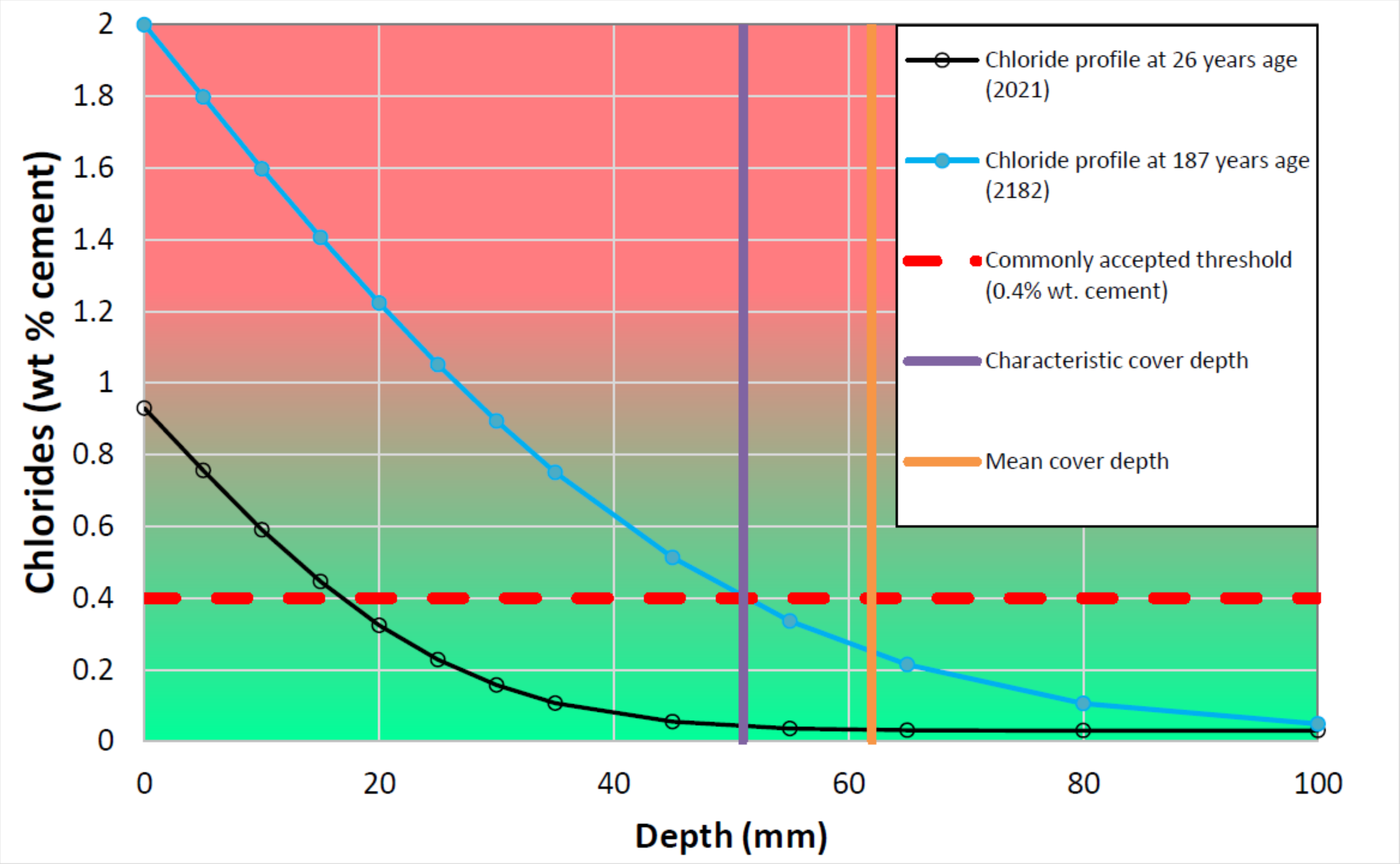


Figure 8: Future predicted chloride diffusion curve for panel X (Xypex Panel), showing service life duration for reinforcement corrosion initiation at the characteristic and mean concrete cover

Extended Service Life – Xypex Benefits

- Many Tests that show much higher durability
- Many project references of real-world examples of much longer service life

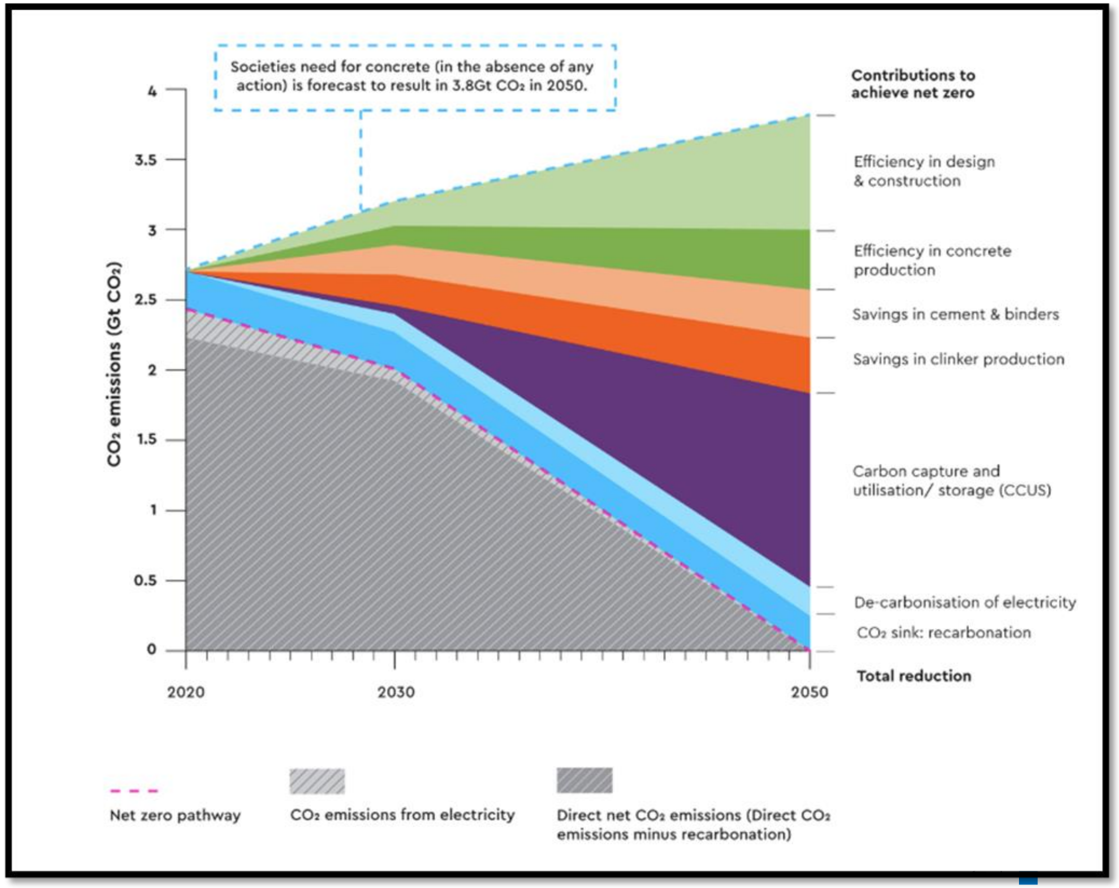
Carbon Footprint

Industry CO_2 Reduction

Concrete Industry – Roadmap to Net Zero

Key Aspects of the Plan for Concrete Producers:

- Savings in Cement and Binders
- Efficiency in Concrete Production
- Efficiency in Design and Construction
- Circularity / Recyclability of Concrete



Quantification and CO_2 Reduction

Efficiency in Design and Construction

- Replaces High Embodied Carbon Waterproofing Materials

Quantification and CO_2 Reduction

Third-Party Verified EPD

- 1.5 pts per product (LEED)
- Xypex C-500 NF Admix- A1-A5 (Manufacturing and Construction)

$$GWP_t = 3.0\ kg/m^3 \times 1.539\ kg\ CO_{2eq}$$

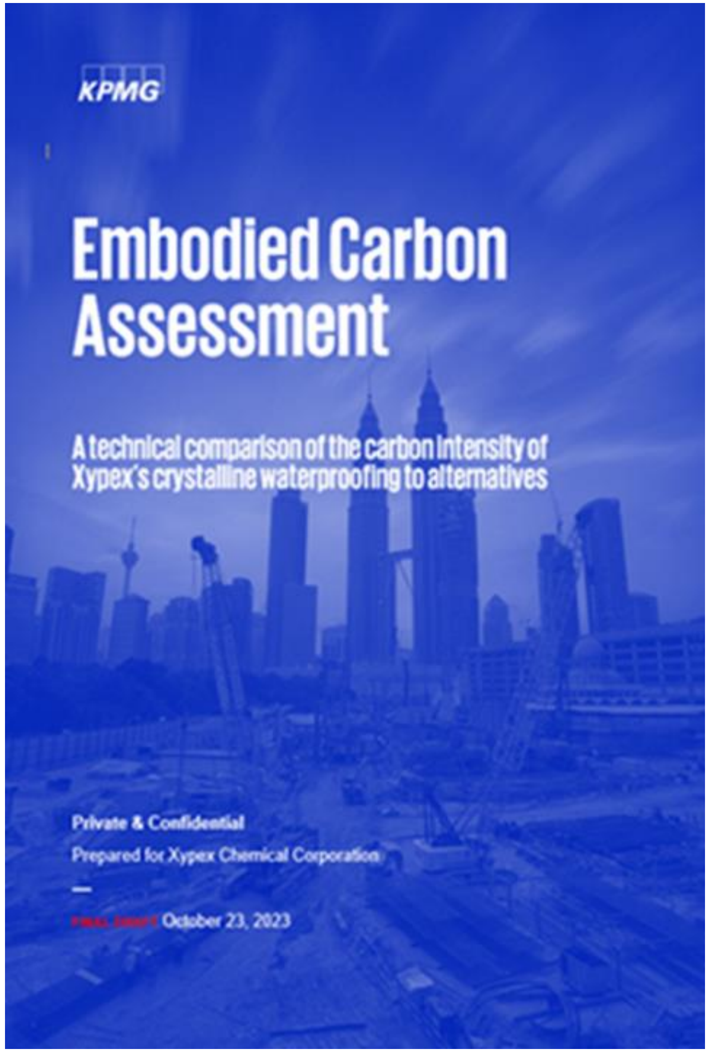
$$= 4.62\ kg\ CO_{2eq}$$

~ 7 kg of Ordinary Portland Cement

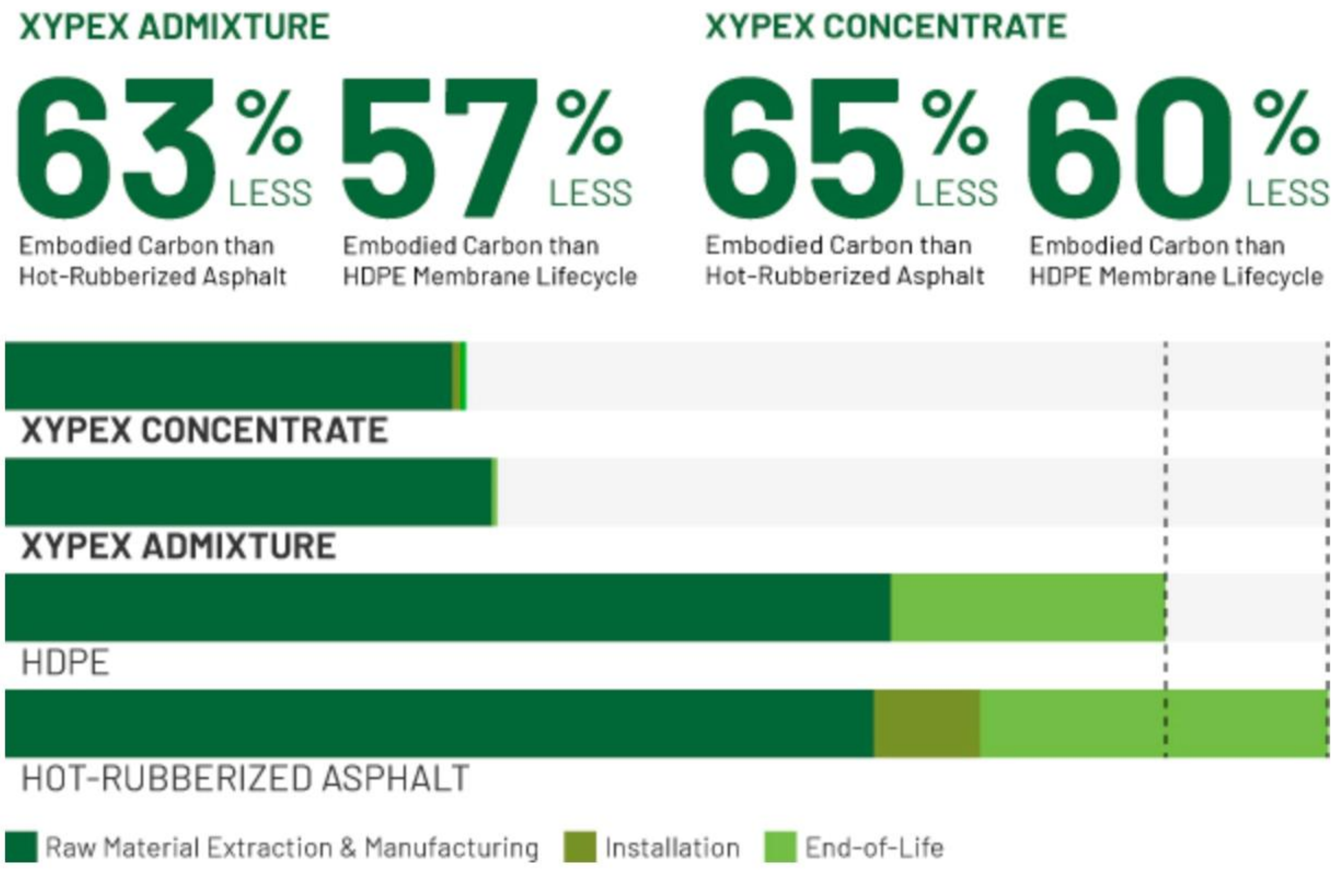
Quantification and CO_2 Reduction

KPMG Embodied Carbon Assessment

- KPMG conducted a Cradle-to-Grave Life Cycle Analysis of:
  - Waterproofing a Below Grade Structure
  - Xypex vs traditional waterproofing
    - Membranes
    - Surface-Applied Asphalt Coatings
  - ~1000 m^2 of surface area



Quantification and CO2 Reduction



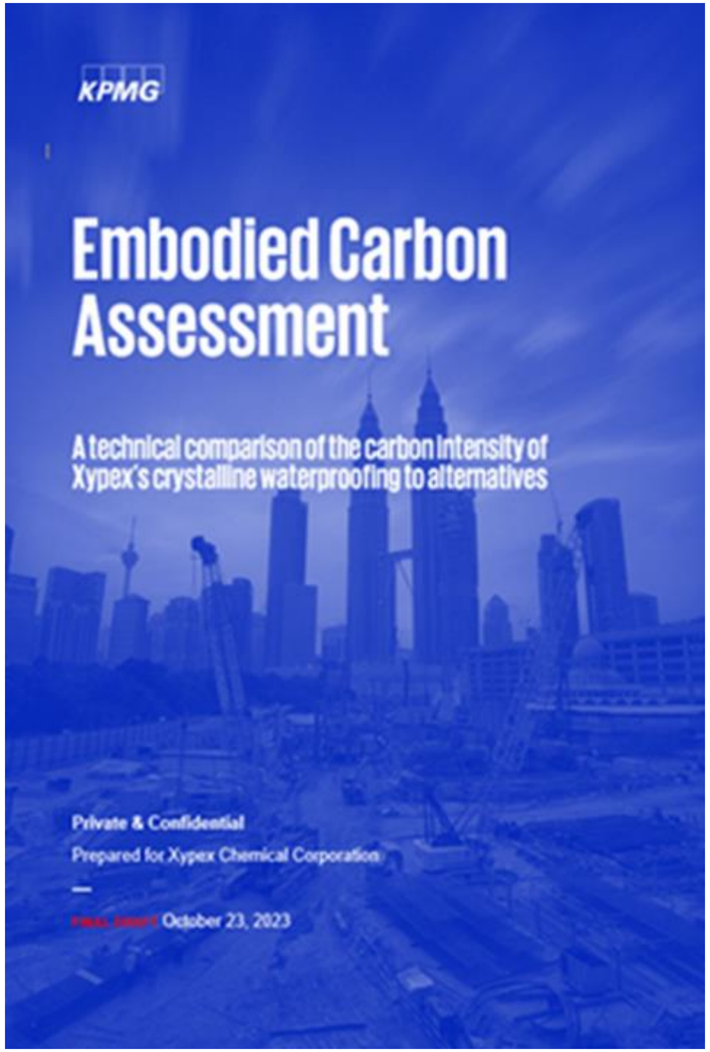
Xypex has 60% Less CO2 Than Traditional Waterproofing

Quantification and CO_2 Reduction

KPMG Embodied Carbon Assessment

- The Study found that there was a large potential for further CO_2 savings due to Extended Service Life and Avoided Repairs.

- This was not included in the study



Industry CO_2 Reduction

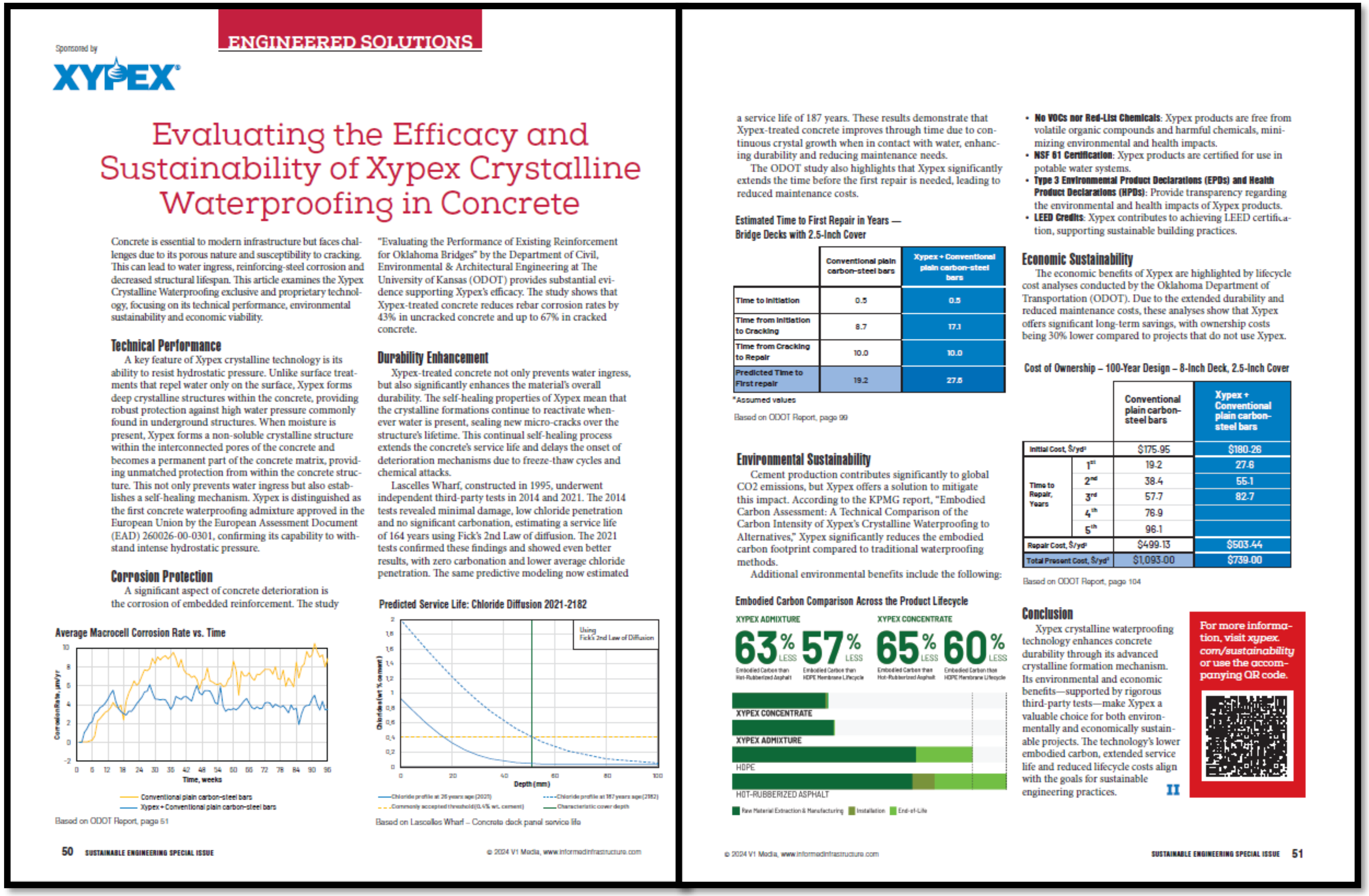
Circularity / Recyclability of Concrete

- Less reliance on Virgin Materials
- Greater use of Recycled Materials

Concrete with Xypex is Fully Recyclable

Evaluating the Efficacy and Sustainability of Xypex Crystalline Waterproofing in Concrete

XYPEX®



ENGINEERED SOLUTIONS

Sponsored by XYPEX

Evaluating the Efficacy and Sustainability of Xypex Crystalline Waterproofing in Concrete

Concrete is essential to modern infrastructure but faces challenges due to its porous nature and susceptibility to cracking. This can lead to water ingress, reinforcing-steel corrosion and decreased structural lifespan. This article examines the Xypex Crystalline Waterproofing exclusive and proprietary technology, focusing on its technical performance, environmental sustainability and economic viability.

Technical Performance

A key feature of Xypex crystalline technology is its ability to resist hydrostatic pressure. Unlike surface treatments that repel water only on the surface, Xypex forms deep crystalline structures within the concrete, providing robust protection against high water pressure commonly found in underground structures. When moisture is present, Xypex forms a non-soluble crystalline structure within the interconnected pores of the concrete and becomes a permanent part of the concrete matrix, providing unmatched protection from within the concrete structure. This not only prevents water ingress but also establishes a self-healing mechanism. Xypex is distinguished as the first concrete waterproofing admixture approved in the European Union by the European Assessment Document (EAD) 260026-00-0301, confirming its capability to withstand intense hydrostatic pressure.

Corrosion Protection

A significant aspect of concrete deterioration is the corrosion of embedded reinforcement. The study "Evaluating the Performance of Existing Reinforcement for Oklahoma Bridges" by the Department of Civil, Environmental & Architectural Engineering at The University of Kansas (ODOT) provides substantial evidence supporting Xypex's efficacy. The study shows that Xypex-treated concrete reduces rebar corrosion rates by 43% in uncracked concrete and up to 67% in cracked concrete.

Durability Enhancement

Xypex-treated concrete not only prevents water ingress, but also significantly enhances the material's overall durability. The self-healing properties of Xypex mean that the crystalline formations continue to reactivate whenever water is present, sealing new micro-cracks over the structure's lifetime. This continual self-healing process extends the concrete's service life and delays the onset of deterioration mechanisms due to freeze-thaw cycles and chemical attacks.

Lascelles Wharf, constructed in 1995, underwent independent third-party tests in 2014 and 2021. The 2014 tests revealed minimal damage, low chloride penetration and no significant carbonation, estimating a service life of 164 years using Fick's 2nd Law of diffusion. The 2021 tests confirmed these findings and showed even better results, with zero carbonation and lower average chloride penetration. The same predictive modeling now estimated a service life of 187 years. These results demonstrate that Xypex-treated concrete improves through time due to continuous crystal growth when in contact with water, enhancing durability and reducing maintenance needs.

The ODOT study also highlights that Xypex significantly extends the time before the first repair is needed, leading to reduced maintenance costs.

Average Macrocell Corrosion Rate vs. Time

Conventional plain carbon-steel bars
Xypex + Conventional plain carbon-steel bars

Based on ODOT Report, page 51

Predicted Service Life: Chloride Diffusion 2021-2182

Using Fick's 2nd Law of Diffusion

Based on Lascelles Wharf – Concrete deck panel service life

Estimated Time to First Repair in Years — Bridge Decks with 2.5-Inch Cover

	Conventional plain carbon-steel bars	Xypex + Conventional plain carbon-steel bars
Time to Initiation	0.5	0.5
Time from Initiation to Cracking	8.7	17.1
Time from Cracking to Repair	10.0	10.0
Predicted Time to First repair	19.2	27.6

*Assumed values

Based on ODOT Report, page 99

Environmental Sustainability

Cement production contributes significantly to global CO2 emissions, but Xypex offers a solution to mitigate this impact. According to the KPMG report, "Embodied Carbon Assessment: A Technical Comparison of the Carbon Intensity of Xypex's Crystalline Waterproofing to Alternatives," Xypex significantly reduces the embodied carbon footprint compared to traditional waterproofing methods.

Additional environmental benefits include the following:

- **No VOCs nor Red-List Chemicals**: Xypex products are free from volatile organic compounds and harmful chemicals, minimizing environmental and health impacts.
- **NSF 61 Certification**: Xypex products are certified for use in potable water systems.
- **Type 3 Environmental Product Declarations (EPDs) and Health Product Declarations (HPDs)**: Provide transparency regarding the environmental and health impacts of Xypex products.
- **LEED Credits**: Xypex contributes to achieving LEED certification, supporting sustainable building practices.

Embodied Carbon Comparison Across the Product Lifecycle

XYPEX ADMIXTURE: 63% LESS Embodied Carbon than Hot-Rubberized Asphalt; 57% LESS Embodied Carbon than HDPE Membrane Lifecycle

XYPEX CONCENTRATE: 65% LESS Embodied Carbon than Hot-Rubberized Asphalt; 60% LESS Embodied Carbon than HDPE Membrane Lifecycle

XYPEX CONCENTRATE
XYPEX ADMIXTURE
HDPE
HOT-RUBBERIZED ASPHALT
Raw Material Extraction & Manufacturing · Installation · End-of-Life

Economic Sustainability

The economic benefits of Xypex are highlighted by lifecycle cost analyses conducted by the Oklahoma Department of Transportation (ODOT). Due to the extended durability and reduced maintenance costs, these analyses show that Xypex offers significant long-term savings, with ownership costs being 30% lower compared to projects that do not use Xypex.

Cost of Ownership – 100-Year Design – 8-Inch Deck, 2.5-Inch Cover

		Conventional plain carbon-steel bars	Xypex + Conventional plain carbon-steel bars
Initial Cost, $/yd²		$175.95	$180.26
Time to Repair, Years	1st	19.2	27.6
	2nd	38.4	55.1
	3rd	57.7	82.7
	4th	76.9	
	5th	96.1	
Repair Cost, $/yd²		$499.13	$503.44
Total Present Cost, $/yd²		$1,093.00	$739.00

Based on ODOT Report, page 104

Conclusion

Xypex crystalline waterproofing technology enhances concrete durability through its advanced crystalline formation mechanism. Its environmental and economic benefits—supported by rigorous third-party tests—make Xypex a valuable choice for both environmentally and economically sustainable projects. The technology's lower embodied carbon, extended service life and reduced lifecycle costs align with the goals for sustainable engineering practices. II

For more information, visit xypex.com/sustainability or use the accompanying QR code.

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Questions and Answers

Waterproofing by Crystallization