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Crystalline Concrete Comparison

Xypex C1000NF, Penetron Admix and Krystaline Add1

The following report is based on independent testing conducted by the University of Architecture, Civil Engineering and Geodesy, University Construction Testing Laboratory (USIL)

Accreditation Certificate No 239 LI/15.08.2018 with validity till 15.08.2022 in accordance with BDS EN ISO/IEC 17025:2006

The test reports used in this report are as follows:

Nº CM 278-19/10.07.2019

Nº CM 279-19/10.07.2019

Nº CM 281-19/10.07.2019

Nº CM 282-19/10.07.2019

Nº CM 284-19/10.07.2019

Nº CM 285-19/10.07.2019

Nº CM 287-19/10.07.2019

Nº CM 288-19/10.07.2019

Nº CM 290-19/10.07.2019

Nº CM 291-19/10.07.2019

Nº CM 293-19/10.07.2019

Nº CM 294-19/10.07.2019

Nº CM 296-19/10.07.2019

Nº CM 297-19/10.07.2019

Nº CM 299-19/10.07.2019

Nº CM 300-19/10.07.2019

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Dosage

Addition quantities of the crystalline admixtures used in the mix design for the testing:

|	Dosage kg/m³	Notes
Reference Concrete	0.0 kg/m³	Reference concrete without admixture
Xypex C1000NF	4.5 kg/m³	Added as a percentage of cement
Penetron Admix	3.0 kg/m³	Added as a percentage of cement
Krystaline Add1	1.0 kg/m³	Always 1 kg dosage only

Comparison of different cement contents and the dosages that would be required:

Cement Content per m³	Xypex C1000NF	Penetron Admix	Krystaline Add1
300 kg per m³	4.5 kg	3 kg	1 kg
350 kg per m³	5.25 kg	3.5 kg	1 kg
400 kg per m³	6 kg	4 kg	1 kg
450 kg per m³	6.75 kg	4.5 kg	1 kg

Notes:
As indicated in the above tables, when working with Xypex C1000NF, Penetron Admix and Krystaline Add1, per kg pricing will not provide an accurate cost comparison. **All products need to be compared by the cost per m³ of concrete to have an accurate indication of cost.**

Krystaline Add1 has the added advantage of being a consistent 1 kg per m³ addition rate, as such the dosages used here based on a 300 kg cementitious content would change significantly if the cement content would increase. Using Krystaline Add1 eliminates the calculations and provides consistent cost calculations regardless of the cement content of the concrete.
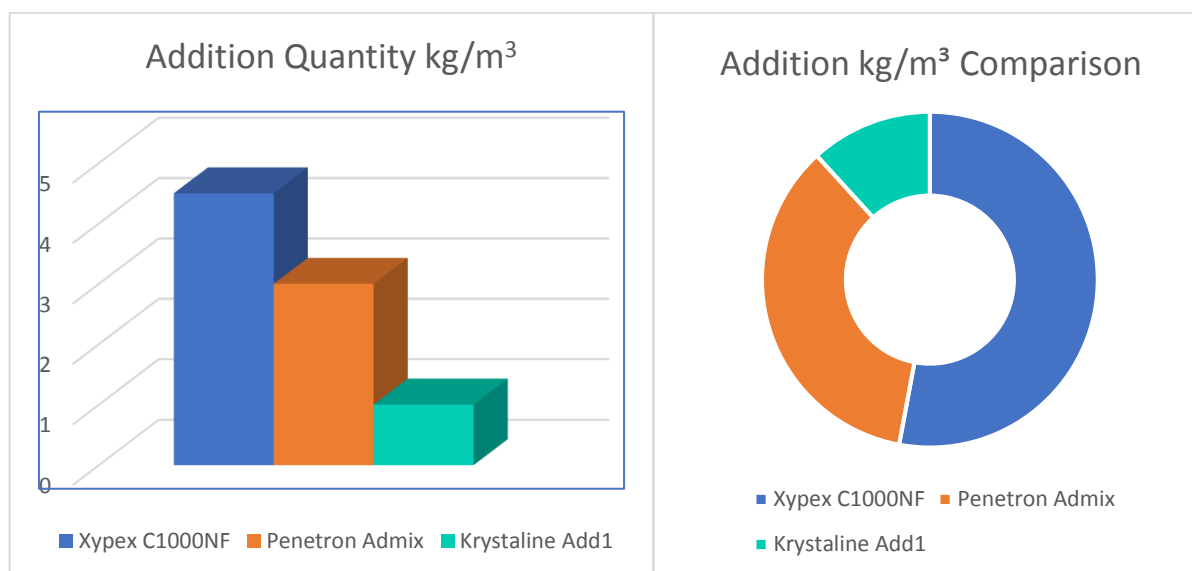
The dramatic difference in dosage rates used in this concrete mix design can be translated between all the 3 products as 350% more Xypex C1000NF and 300% more Penetron Admix than Krystaline Add1 within this specific design mix.

As is immediately obvious in the above graphs, **per kg pricing will not provide the true costs** for waterproofing a specific volume of concrete due to the dramatic difference in dosing.

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Water/Cement Ratio

The w/c ratios used to achieve equal slump concrete to the reference concrete:

	W/C ratio used for equal slump	Notes
Reference Concrete	0.760	0% difference (reference concrete)
Xypex C1000NF	0.689	9.7% reduction of water
Penetron Admix	0.720	5.6% reduction of water
Krystaline Add1	0.701	9.2% reduction of water

Notes:

The below chart shows the w/c ratio for the reference concrete and all three crystalline admixtures based on equal slump concrete. All three of the admixtures had a water reduction effect compared to the reference concrete effectively lowering the w/c ratio.
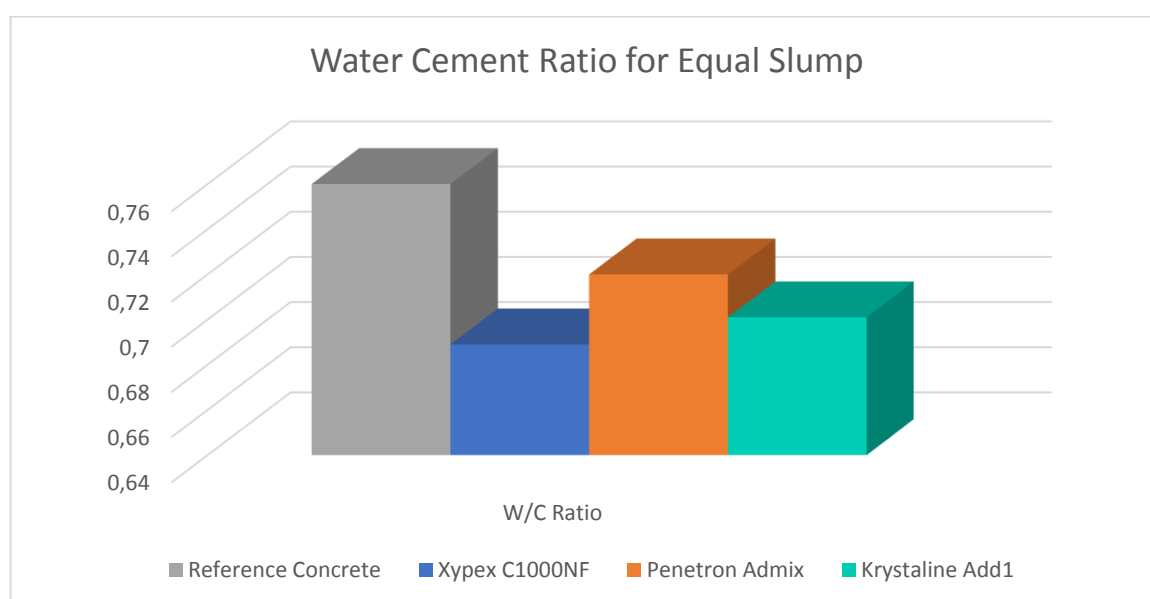
When we convert the differences between the 3 admixtures it is easily noted (see below graph) that Xypex C1000NF (with 9.7% water reduction) and Krystaline Add1 (with 9.2% water reduction) have the greatest effect. Penetron resulted in a notably lower result with only 5.6% water reduction.

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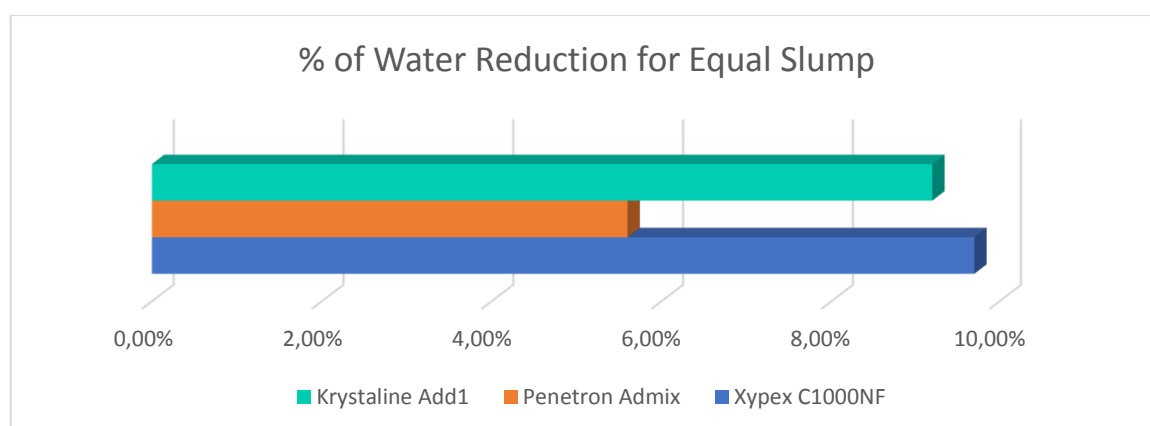
Slump

Initial slump and slump retention at 30, 60 and 90 minutes for reference and crystalline concretes:
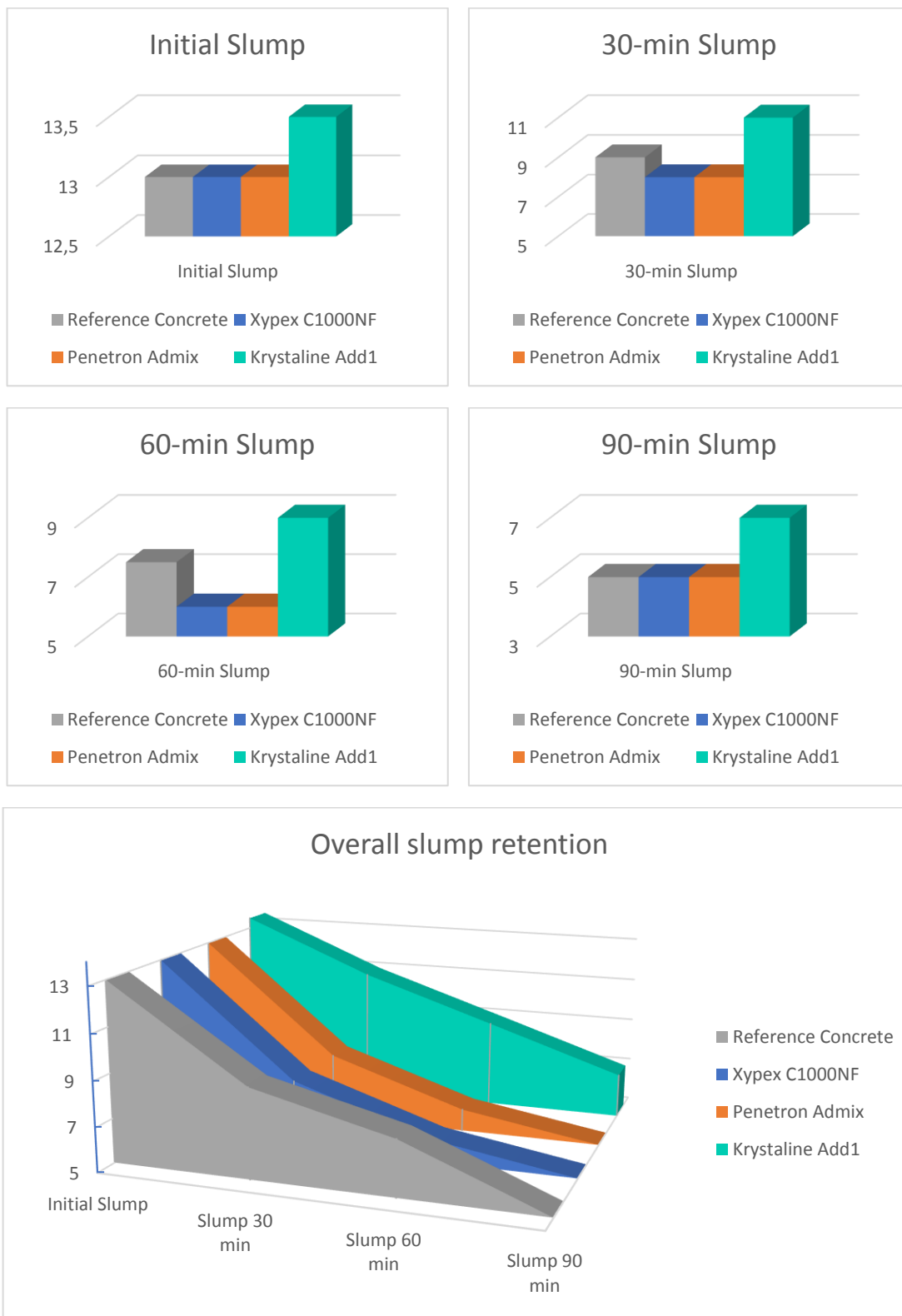
	Slump	Notes
Reference Concrete Initial Slump	13.0	Reference concrete
Reference Concrete 30-minute Slump	9.0	Reference concrete
Reference Concrete 60-minute Slump	7.5	Reference concrete
Reference Concrete 90-minute Slump	5.0	Reference concrete
Xypex C1000NF Initial Slump	13.0	**0% increase** in slump retention between reference concrete and Xypex treated concrete
Xypex C1000NF 30-minute Slump	8.0	**-11% increase** in slump retention at 30 minutes between reference concrete and Xypex C1000NF
Xypex C1000NF 60-minute Slump	6.0	**-20% increase** in slump retention at 60 minutes between reference concrete and Xypex C1000NF
Xypex C1000NF 90-minute Slump	5.0	**0% increase** in slump retention at 90 minutes between reference concrete and Xypex C1000NF
Penetron Admix Initial Slump	13.0	**0% increase** in slump retention between reference concrete and Penetron Admix
Penetron Admix 30-minute Slump	8.0	**-11% increase** in slump retention at 30 minutes between reference concrete and Penetron Admix
Penetron Admix 60-minute Slump	6.0	**-20% increase** in slump retention at 60 minutes between reference concrete and Penetron Admix
Penetron Admix 90-Minute Slump	5.0	**0% increase** in slump retention at 90 minutes between reference concrete and Penetron Admix
Krystaline Add1 Initial Slump	13.5	**3.8% % increase** in slump retention between reference concrete and Krystaline Add1
Krystaline Add1 30-minute Slump	11.0	**22% increase** in slump retention at 30 minutes between reference concrete and Krystaline Add1
Krystaline Add1 60-minute Slump	9.0	**20% increase** in slump retention at 60 minutes between reference concrete and Krystaline Add1
Krystaline Add1 90-minute Slump	7.0	**40% increase** in slump retention at 90 minutes between reference concrete and Krystaline Add1

Notes:

The initial slump for the reference concrete, the Xypex C1000NF concrete and the Penetron Admix concrete were all 13 cm. The Krystaline Add1 concrete resulted in a 13.5 cm initial slump increase (higher by 3.8%). The increased slump of the Krystaline Add1 mix is still within the normative for testing and is perfectly acceptable. It should be noted that this does indicate that the w/c ratio could actually have been lowered further to result in a 13 cm slump.

The following series of graphs show the slump loss over time including initial slump, 30-minute slump, 60-minute slump and 90-minute slump.

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Slump – part 2

Initial Slump

30-min Slump

60-min Slump

90-min Slump

Overall slump retention

Xypex C1000NF and Penetron Admix possessed the same or lower slump retention than the reference concrete. The only product to enhance the slump retention was Krystaline Add1.

Krystaline Add1 provided a consistent and controlled reduction of slump. It should be noted the Reference Concrete, Xypex C1000NF and Penetron Admix all had very rapid decreases within the first 30 minutes, while Krystaline Add1 provided consistent slump retention loss and was always above the reference concrete.

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Density

	Density (kg/m³)	Mean Density (kg/m³)	Notes
Reference Concrete	2330	2310	Reference concrete
	2320		
	2280		
Xypex C1000NF	2300	2290	Results show a 0.86% reduction in the density of the concrete.
	2300		
	2270		
Penetron Admix	2320	2333	Results show a 1.00% *increase* in the density of the concrete.
	2320		
	2360		
Krystaline Add1	2270	2287	Results show a 1.00% reduction in the density of the concrete.
	2300		
	2290		

Notes:

Concrete density is the mass per unit volume of concrete. In most concrete tests as the w/c ratio drops the density increases if all other components are constant. Crystalline technology however contradicts this rule, so a product with a true crystalline nature will lower the density while also lowering the water/cement ratio and result in strength gains and increased permeability. Products that increase density are densifiers and should be approached as a densification technology not a crystalline technology.
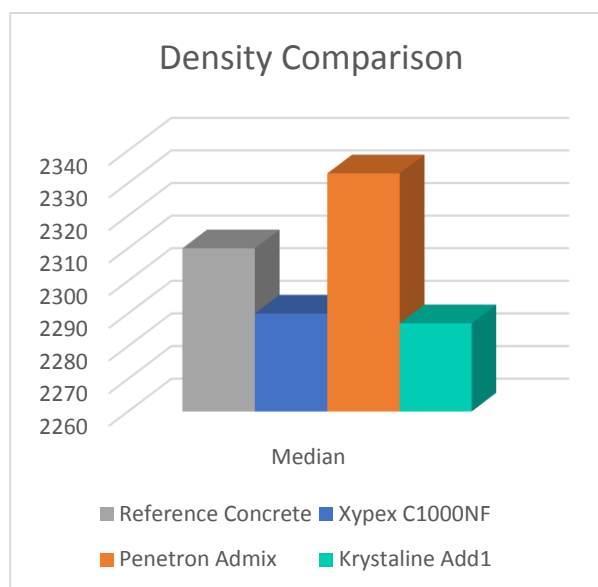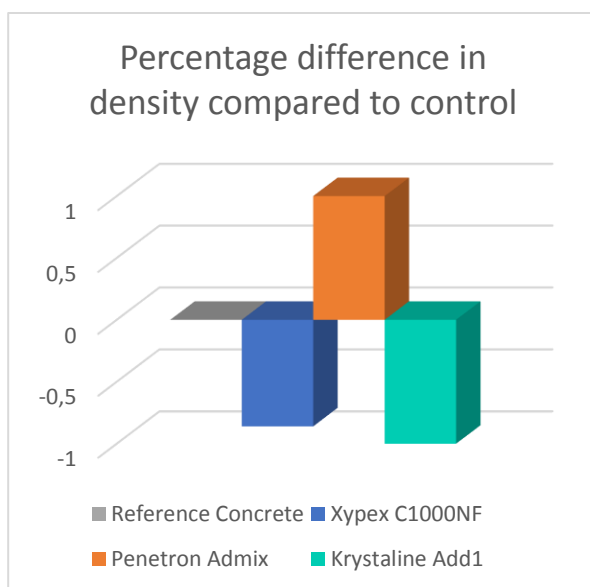

As can be seen in the above graphs:
- Penetron Admix **increases** the density of the concrete.
- Xypex C1000NF **reduces** the density of the concrete.
- Krystaline Add1 **reduces** the density of the concrete.

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Compressive Strength

	Compressive Strength (MPa)	Mean Compressive Strength (MPa)	Notes
Reference Concrete	27.60 27.40 26.90	27.90	Reference concrete
Xypex C1000NF	37.10 34.80 34.90	35.60	27.60% increase in compressive strength compared to reference concrete.
Penetron Admix	32.10 31.00 32.00	31.70	13.60% increase in compressive strength compared to reference concrete.
Krystaline Add1	37.50 39.30 38.40	38.40	37.60% increase in compressive strength compared to reference concrete.

Notes:

Compressive Strength Comparison by Total MPa
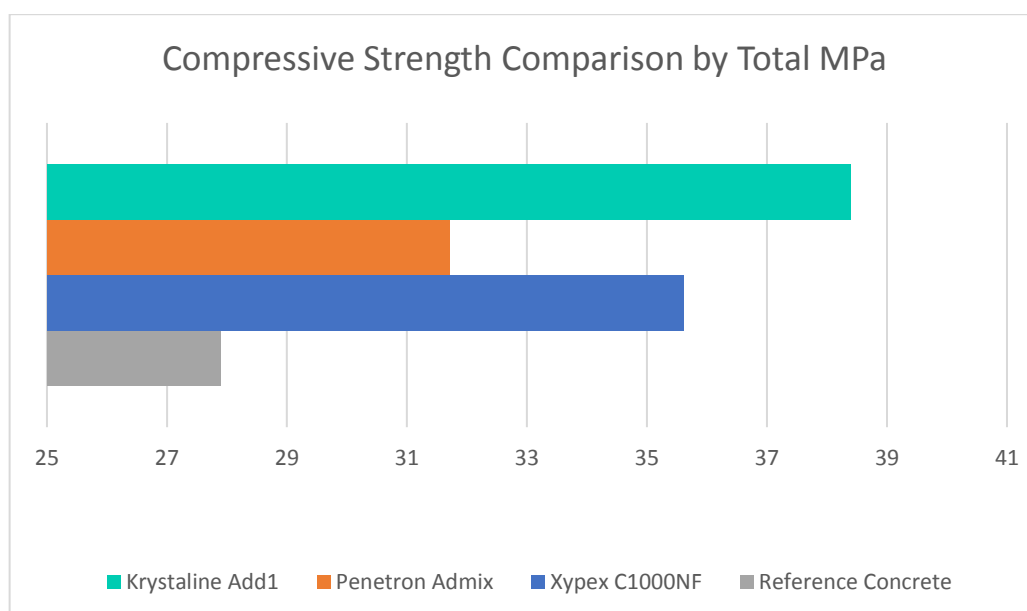
Krystaline Add1 clearly resulted in higher compressive strength compared to the other concretes as can be noted by:

- 37.5% higher strength than reference Concrete
- 7.86% higher strength than Xypex C1000NF
- 21.14% higher strength than Penetron Admix

As can be noted in the above table and graph, Krystaline Add1 treated concrete substantially increased compressive strength MPa over the other concretes

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Compressive Strength – part 2

In the below tables, each crystalline treated concrete is compared in percentage strength gain or loss against the reference concrete, Penetron Admix and Krystaline Add1.

Compressive Strength Gain/Loss Compared to Xypex C1000NF Concrete

Xypex C1000NF	Reference Concrete	Penetron Admix	Krystaline Add1
100% - Control	21.63% - Loss	10.96% - Loss	7.86% - Gain

- Xypex C1000NF resulted in a compressive strength increase compared to Penetron Admix
- Xypex C1000NF resulted in a compressive strength decrease compared to Krystaline Add1

Compressive Strength Gain/Loss Compared to Penetron Admix Concrete

| Penetron Admix	Reference Concrete	Xypex C1000NF	Krystaline Add1
100% - Control	11.99% - Loss	12.30% - Gain	21.14% - Gain

- Penetron Admix resulted in a compressive strength decrease compared to Xypex C1000NF
- Penetron Admix resulted in a compressive strength decrease compared to Krystaline Add1

Compressive Strength Gain/Loss Compared to Krystaline Add1 Concrete

Krystaline Add1	Reference Concrete	Xypex C1000NF	Penetron Admix
100% - Control	27.34% - Loss	7.29% - Loss	17.45% - Loss

- Krystaline Add1 resulted in a compressive strength increase compared to Xypex C1000NF
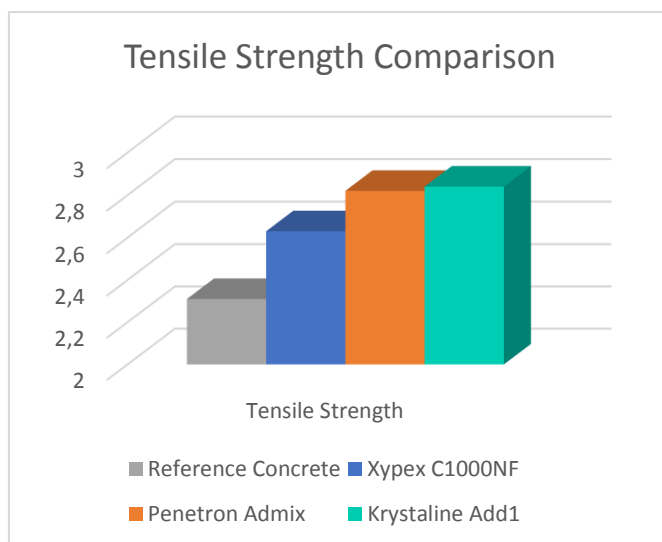- Krystaline Add1 resulted in a compressive strength increase compared to Penetron Admix

The following graph provides a visual representation of each concrete (used as control "0") in comparison to the other tested concretes.

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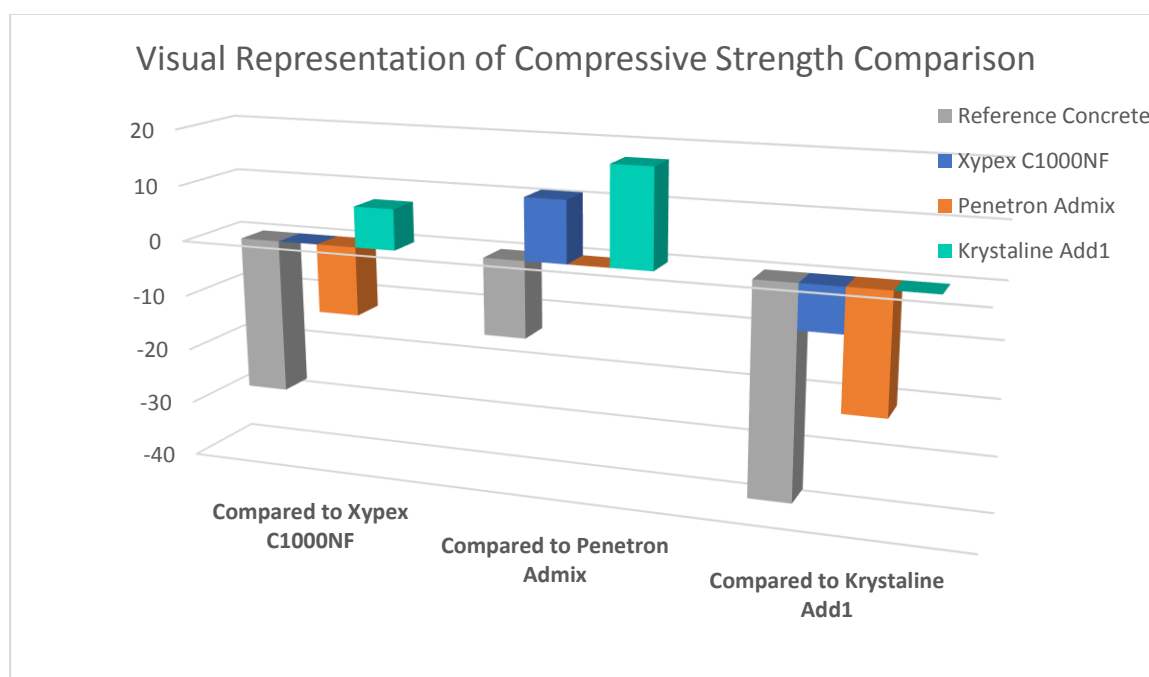
Tensile Strength

|	Tensile Strength (MPa)	Mean Tensile Strength (MPa)	Notes
Reference Concrete	2.21	2.31	Reference concrete
	2.46		
	2.26		
Xypex C1000NF	2.80	2.63	12.55% increase in tensile strength compared to reference concrete.
	2.83		
	2.26		
Penetron Admix	2.72	2.82	22.70% increase in tensile strength compared to reference concrete.
	2.80		
	2.94		
Krystaline Add1	2.72	2.84	22.90% increase in tensile strength compared to reference concrete.
	2.80		
	2.94		

Notes:

Krystaline Add1 resulted in the highest tensile strength with Penetron Admix a very close second.

22.90% higher than reference concrete.

7.39% higher than Xypex C1000NF.

0.70% higher than Penetron Admix.

The following graph provides a visual representation of each concrete (used as control "0") in comparison to the other tested concretes.

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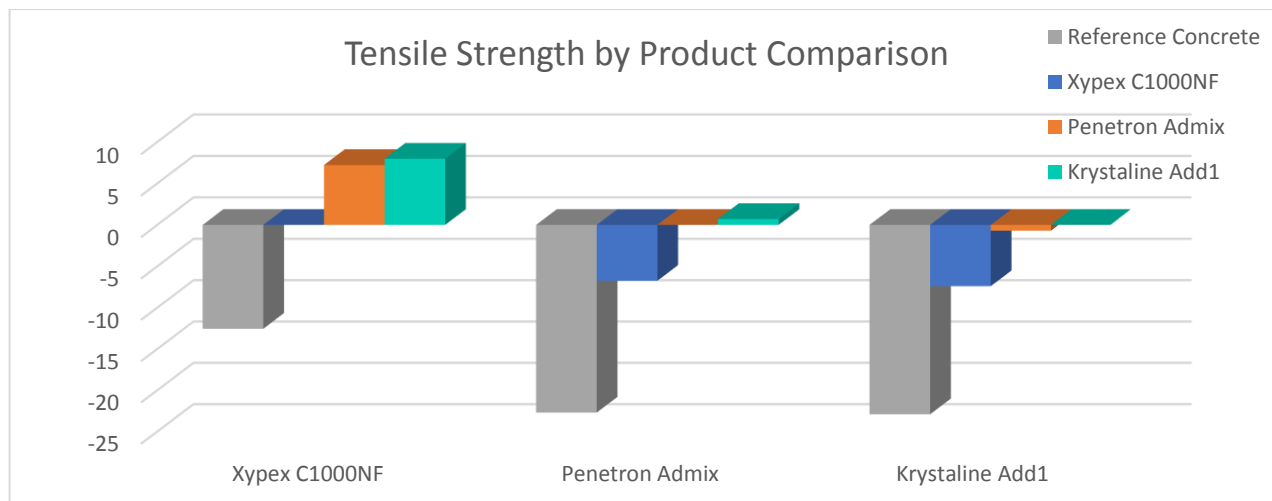
Water Penetration

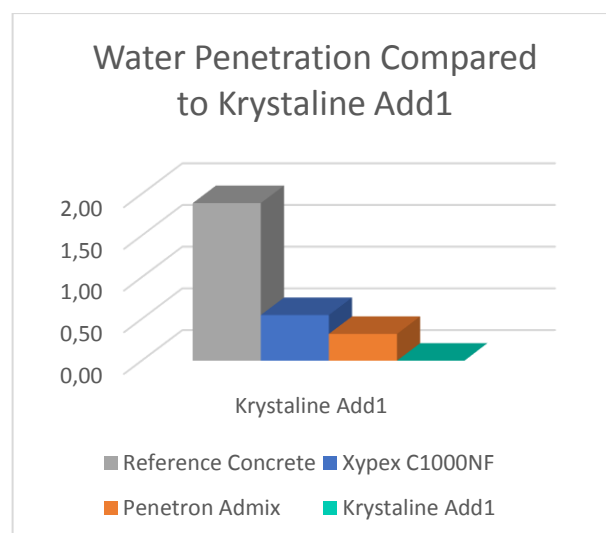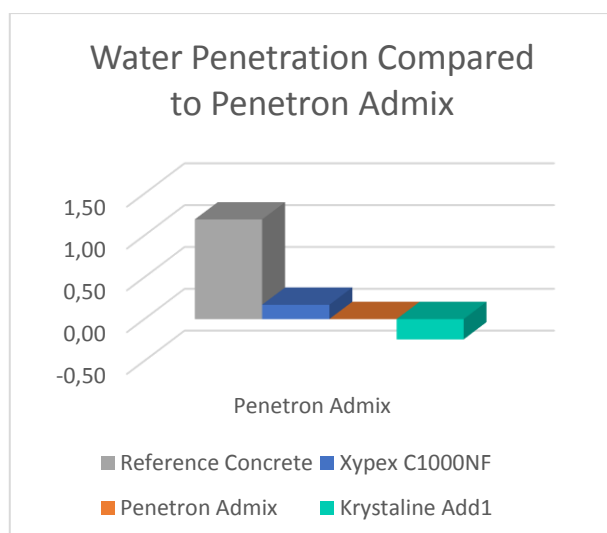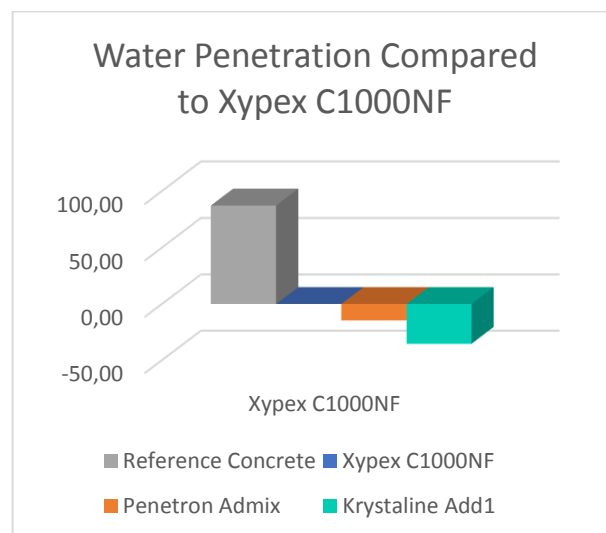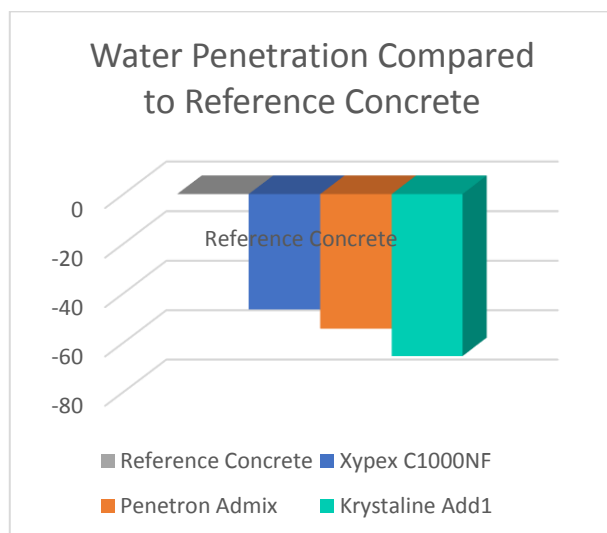|	Depth of Penetration (mm)	Mean Penetration (mm)	Notes
Reference Concrete	52 38 37	42.3	Reference concrete
Xypex C1000NF	15 32 21	22.6	46.57% less water penetration than reference concrete.
Penetron Admix	14 24 20	19.3	54.37% less water penetration than reference concrete.
Krystaline Add1	15 14 15	14.6	65.48% less water penetration than reference concrete.

Notes:
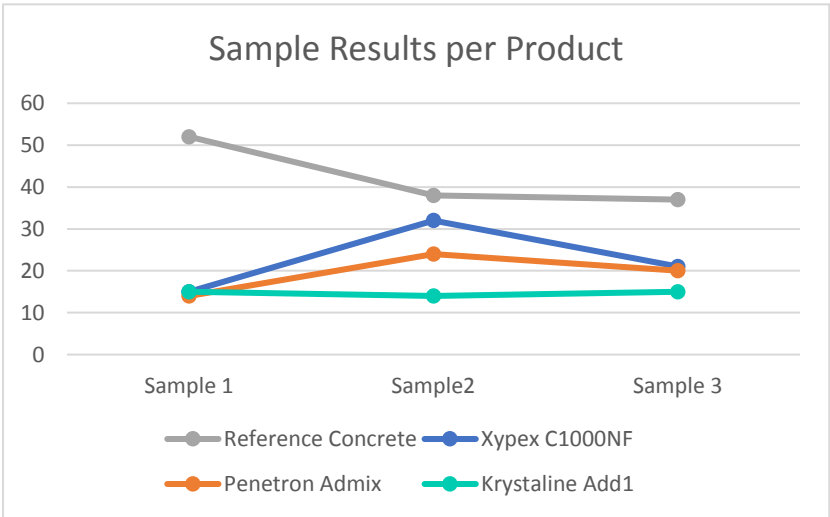
The results of 3 samples each for the reference concrete and each of the crystalline products concrete are shown in the graph. It should be noted that Krystaline Add1 has shown consistency in the results with virtually no variation.
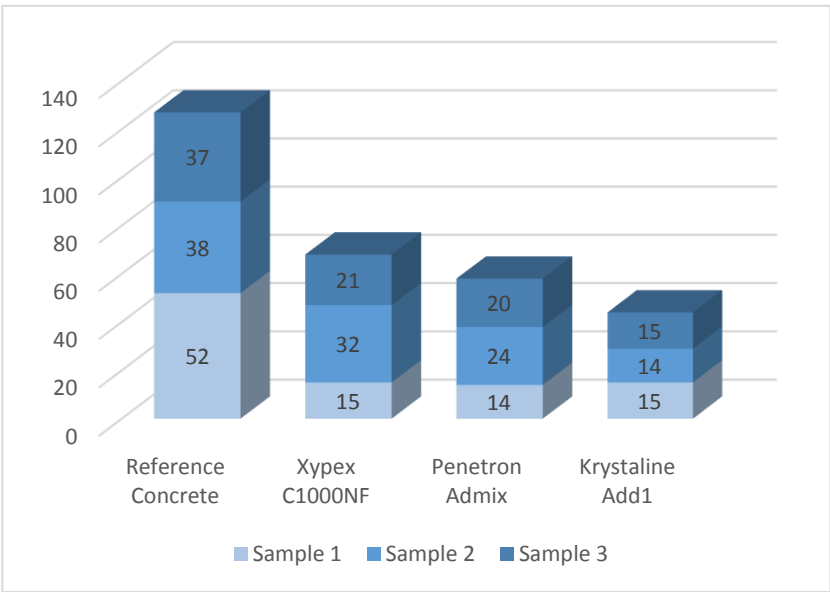
This graph shows a cumulative total for all three samples for each product. As can be noted the overall water penetration for the Krystaline Add1 samples when all samples are considered is dramatically lower. This is a very strong statement for the reduction of water penetration of concrete over a large area

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Water Penetration – part 2

The following series of graphs show each individual product compared to the others directly with each individual treated concrete as a base for the comparison:

Water Penetration Compared to Reference Concrete

Water Penetration Compared to Xypex C1000NF

Water Penetration Compared to Penetron Admix

Water Penetration Compared to Krystaline Add1

The following graph gives an overall visual representation to the above individual comparisons:

### Water Penetration All Comparatives
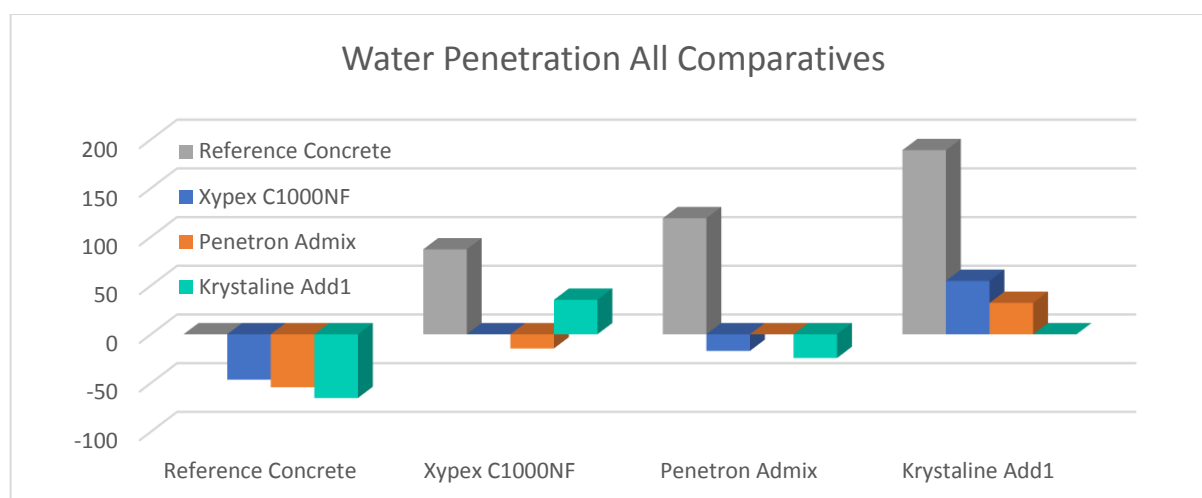
As per the tables and graphs, it can be noted that Krystaline Add1 stands out as the overall best product for reducing water penetration in concrete by a noticeable difference.

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Static modulus of Elasticity

	Static Modulus of Elasticity (MPa)	Notes
Reference Concrete	28011	0% difference (reference concrete)
Xypex C1000NF	29636	5.48% increase over reference concrete
Penetron Admix	28540	1.85% increase over reference concrete
Krystaline Add1	30384	7.81% increase over reference concrete

As can be noted Krystaline Add1 increases the static modulus of elasticity over control by almost 8%. The below graph provides a visual indication of the difference between each concrete.
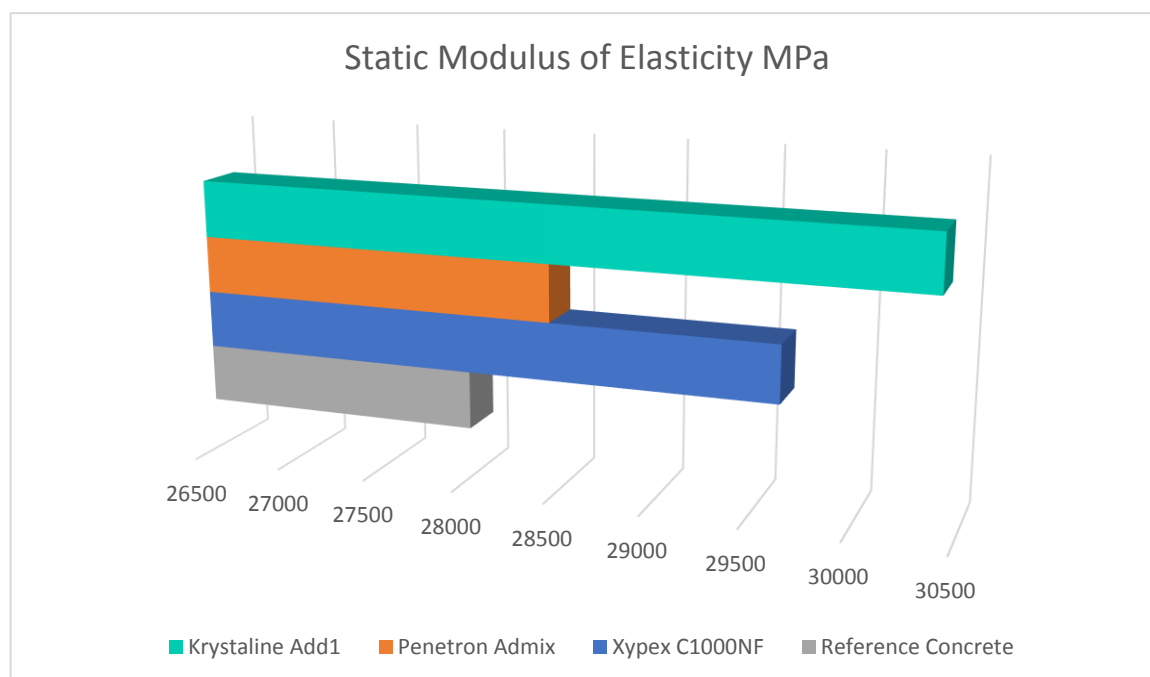

It should be noted that Krystaline Add1 provides a notable difference in the static modulus of elasticity.

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Freeze/Thaw (Accelerated Method)

	Cycles - Class	Pass/Fail	Notes
Reference Concrete	2 cycles – class 75	Pass	1.9% weight loss
	3 cycles – class 100	**Fail**	2.6% weight loss
	4 cycles – class 150	-	-
Xypex C1000NF	2 cycles – class 75	Pass	1.68% weight loss
	3 cycles – class 100	Pass	1.75% weight loss
	4 cycles – class 150	**Fail**	2.16% weight loss
Penetron Admix	2 cycles – class 75	Pass	1.75% weight loss
	3 cycles – class 100	Pass	1.89% weight loss
	4 cycles – class 150	**Fail**	3.07% weight loss
Krystaline Add1	2 cycles – class 75	Pass	1.27% weight loss
	3 cycles – class 100	Pass	1.75% weight loss
	4 cycles – class 150	Pass	1.93% weight loss

Notes:

When using the accelerated method of freeze/thaw, Krystaline Add1 is the only product that was able to withstand 4 cycles resulting in a 150 frost resistance class. In countries where there are no freeze/thaw issues, this information is still important as it is directly related to how well waterproofed the concrete is. In freeze/thaw testing, water is one of the critical factors resulting in weight loss. The water in the concrete will freeze, expand and cause deterioration of the concrete samples. Only products that are effective at reducing water penetration can achieve reasonable results in this type of test. It is an extremely effective way to determine if concrete is waterproof.

Weight loss % at 2 cycles
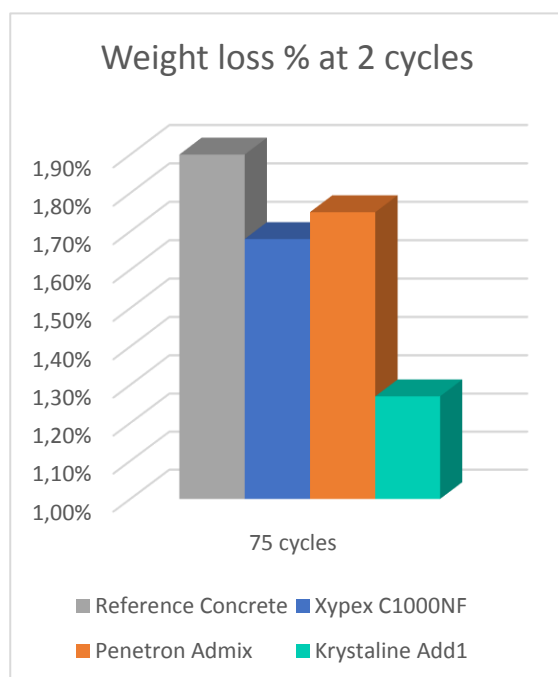
Reference concrete achieved 1.90% weight loss and has passed the 2 cycles – class 75

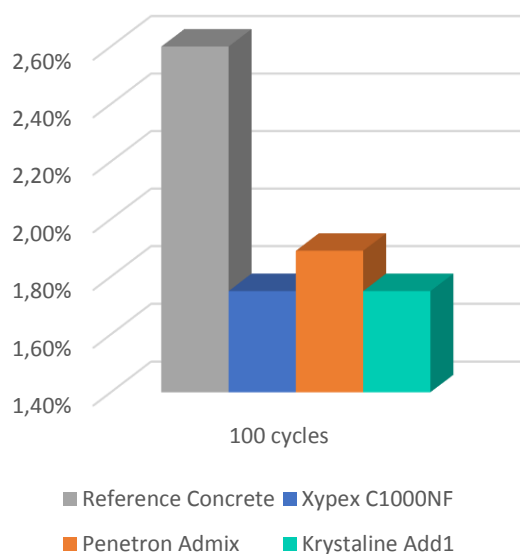Xypex C1000NF achieved 1.68% weight loss and has passed the 2 cycles – class 75.

Penetron Admix achieved 1.75% weight loss and has passed the 2 cycles – class 75.

Krystaline Add1 achieved 1.27% weight loss and has passed the 2 cycles – class 75.

As can be noted in the graph Krystaline Add1 resulted in notably reduced deterioration compared to the other concretes up to 2 cycles – class 75.

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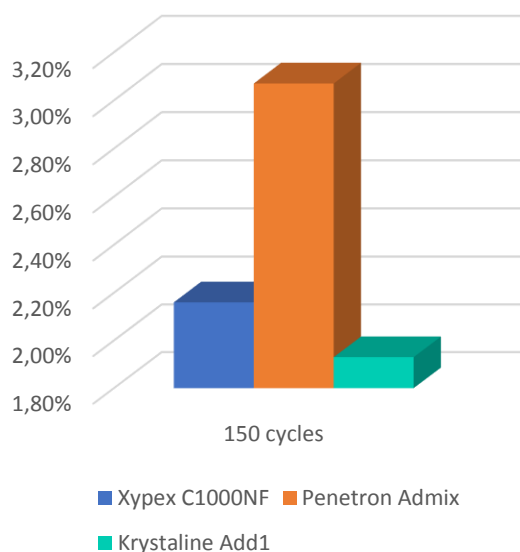**Freeze/Thaw (Accelerated Method) – part 2**

Weight loss % at 3 cycles

Reference concrete resulted in a weight loss of 2.6%, exceeding the 2% weight loss limit of the testing. The maximum achieved successfully 2 cycles – class 75 resulting in a frost resistance class of only 75

Xypex C1000NF achieved 1.75% weight loss and has passed the 3 cycles – class 100.

Penetron Admix achieved 1.89% weight loss and has passed the 3 cycles – class 100.

Krystaline Add1 achieved 1.75% weight loss and has passed the 3 cycles – class 100.

Weight loss % at 4 cycles

Xypex C1000NF resulted in a weight loss of 2.16%, exceeding the 2% weight loss limit of the testing. The maximum achieved successfully is 3 cycles – class 100.

Penetron Admix resulted in an extremely high weight loss of 3.07%, exceeding the 2% weight loss limit of the testing. The maximum achieved successfully is 3 cycles – class 100.

Krystaline Add1 achieved 1.93% weight loss and has passed the 4 cycles – class 150

- Reference concrete only achieved a 75 frost resistance class
- Xypex C1000NF only achieved a 100 frost resistance class.
- Penetron Admix only achieved a 100 frost resistance class.
- Krystaline Add1 achieved a 150 frost resistance class.

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Freeze/Thaw (Ultrasonic Impulse Decrease)

	Cycles	Pass/Fail	Notes
Reference Concrete	2 cycles – class 75	Pass	13.30 decrease
	3 cycles – class 100	**Fail**	15.00 decrease
	4 cycles – class 150	-	-
Xypex C1000NF	2 cycles – class 75	Pass	10.70 decrease
	3 cycles – class 100	Pass	12.90 decrease
	4 cycles – class 150	**Fail**	15.10 decrease
Penetron Admix	2 cycles – class 75	Pass	11.20 decrease
	3 cycles – class 100	Pass	14.90 decrease
	4 cycles – class 150	**Fail**	16.30 decrease
Krystaline Add1	2 cycles – class 75	Pass	11.50 decrease
	3 cycles – class 100	Pass	12.30 decrease
	4 cycles – class 150	Pass	14.50 decrease

Notes:

This method of Freeze/thaw testing involves the use of ultrasonic pulse velocity to determine the homogeneity and quality of the concrete using high frequency sound waves through the concrete sample. A decrease signifies a reduction in the quality of the concrete. This system uses a decrease of 15% as the fail point.

Weight loss % at 2 cycles
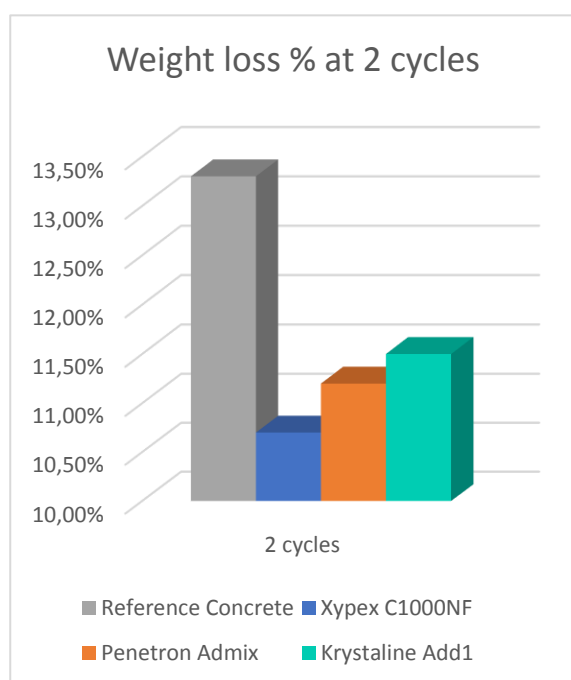
Reference concrete achieved 13.30% weight loss and has passed the 2 cycles – class 75

Xypex C1000NF achieved 10.70% weight loss and has passed the 2 cycles – class 75.
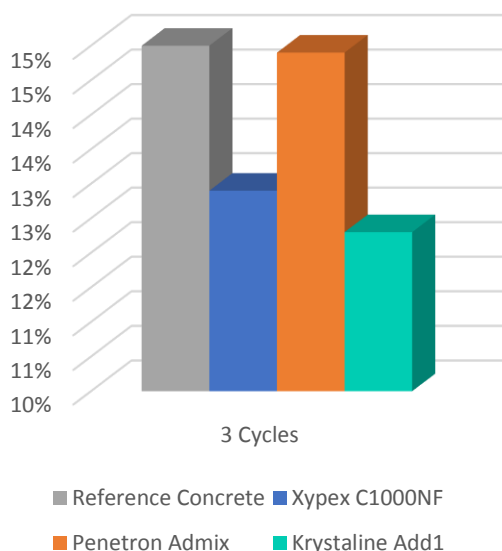
Penetron Admix achieved 11.20% weight loss and has passed the 2 cycles – class 75.

Krystaline Add1 achieved 11.50% weight loss and has passed the 2 cycles – class 75.

As can be noted in the graph Xypex C1000NF resulted in notably reduced deterioration compared to the other concretes up to 2 cycles – class 75.

Freeze/Thaw (Ultrasonic Impulse Decrease) – part 2

Weight loss % at 3 cycles

Reference concrete resulted in a weight loss of 15.00%, reaching the 15.00% weight loss limit of the testing. The maximum achieved by the reference concrete successfully was 2 cycles – resulting in a frost resistance class of only 75
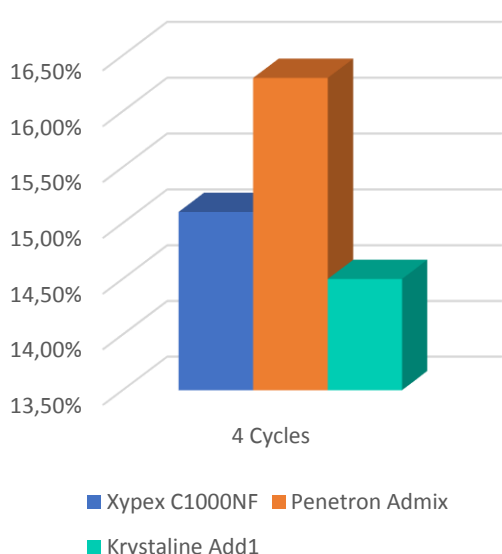
Xypex C1000NF achieved 12.90% weight loss and has passed the 3 cycles – class 100.

Penetron Admix achieved 14.90% weight loss and has passed the 3 cycles – class 100.

Krystaline Add1 achieved 12.30% weight loss and has passed the 3 cycles – class 100.

As can be noted in the graph Krystaline Add1 resulted in notably reduced deterioration compared to the other concretes up to 3 cycles – class 100.

Weight Loss at 4 Cycles

Xypex C1000NF resulted in a weight loss of 15.10%, exceeding the 15.00% weight loss limit of the testing. The maximum achieved successfully is 3 cycles – class 100.

Penetron Admix resulted in an extremely high weight loss of 16.30%, exceeding the 15.00% weight loss limit of the testing. The maximum achieved successfully is 3 cycles – class 100.

Krystaline Add1 achieved 14.50% weight loss and has passed the 4 cycles – class 150

- Reference concrete only achieved a 75 frost resistance class
- Xypex C1000NF only achieved a 100 frost resistance class.
- Penetron Admix only achieved a 100 frost resistance class.
- Krystaline Add1 achieved a 150 frost resistance class.

7-Day Capillary Absorption

	7-Day Capillary Absorption	Notes
Reference Concrete	0.004019	Reference concrete
Xypex C1000NF	0.003042	24.30% reduction of capillary absorption
Penetron Admix	0.003479	13.44% reduction of capillary absorption
Krystaline Add1	0.002521	37.27% reduction of capillary absorption

Notes:
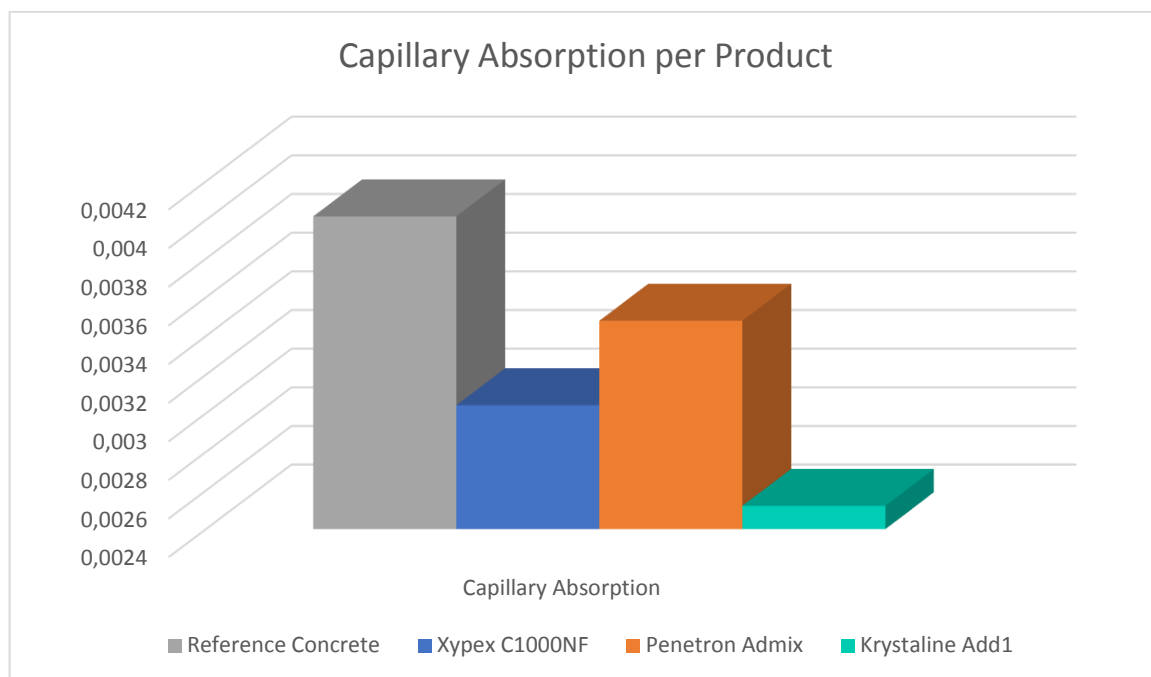
Krystaline Add1 provided a substantially better result for capillary absorption showing an increase of more than 37% over the reference concrete and a notable difference in comparison to the Xypex C1000NF and the Penetron Admix.

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Summary Table

	Xypex C1000NF	Penetron Admix	Krystaline Add1	Notes
Dosage	4.5 kg	3 kg	1 kg	Krystaline had the lowest dosage
Water Reduction	9.7%	5.6%	9.2%	Xypex had the best water reduction
Initial Slump	13 cm	13 cm	13.5 cm	Krystaline had the highest initial slump
30-min Slump	8 cm	8 cm	11 cm	Krystaline had the best 30-min slump retention results
60-min Slump	6 cm	6 cm	9 cm	Krystaline had the highest 60-min slump retention results
90-min Slump	5 cm	5 cm	7 cm	Krystaline had the highest 90-min slump retention results
Density (kg/m³)	2290	2333	2287	Penetron increased density
Compressive Strength (MPa)	35.60	31.70	38.40	Krystaline Add1 had the best compressive strength gains
Tensile Strength (MPa)	2.63	2.82	2.84	Krystaline had the best tensile strength gains
Depth of Penetration	22.6	19.3	14.6	Krystaline had the best depth of penetration results
Modulus of Elasticity (MPa)	29636	28540	30384	Krystaline had the best static modulus of elasticity results
Freeze/thaw Cycles Passed	3 cycles	3 cycles	4 cycles	Krystaline had the freeze/thaw results
Capillary Absorption (g/mm²)	0.003042	0.003479	0.002521	Krystaline had the best capillary absorption results.

Conclusions

1) Not all crystalline admixtures are the same, the tests supporting this report indicate very clearly that the 3 crystalline admixtures used are very distinct in dosage, and performance. Careful consideration should be used in determining the best product to meet the conditions required.

2) All three treated concretes have very different admixture dosing requirements ranging from 4.5 kg/m³ to 1 kg/m³ and as such pricing should always be done on a cubic meter basis rather than a per kg basis.

3) Xypex C1000NF uses a much higher dosage per m³ than either Penetron Admix or Krystaline Add1. Most results were between Penetron Admix and Krystaline Add1, indicating better performance overall than Penetron, but worse than Krystaline Add1. Xypex C1000NF did produce the worst results for the depth of penetration test which is of course a critical test for a crystalline waterproofing product.

4) While all three crystalline admixtures reduce w/c ratio for an equal slump, Penetron Admix reduced the w/c ratio much less than Xypex C1000NF and Krystaline Add1. As water reduction ability is an important part of crystalline technology it is indicative of a possible lower crystalline content or quality. Penetron also was the only crystalline admixture tested that increased density rather than decrease it. Penetron also had the lowest results in strength gain, and the worse results for capillary absorption.

5) The Krystaline Add1 treated concrete showed a lower density, the highest strength gain, the highest reduction in water penetration, the highest tensile strength gain, the highest static modulus of elasticity, was the only product to succeed in 4 cycles for freeze/thaw testing and had dramatically lower capillary absorption than Xypex C1000NF and Penetron Admix.

6) **The results clearly indicate that Krystaline Add1 concrete is more durable and sustainable than Xypex C1000NF and Penetron Admix.**

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