



Concrete Waterproofing by Crystallization™
Concrete Durability Enhancement by Crystallization™

**WATER ABSORPTION,
WATER PERMEABILITY, &
RTA SORPTIVITY TEST ON
XYPEX ADMIX C-SERIES (C-1000NF) MODIFIED
COMMERCIAL CONCRETES.**

*Joint Research Project by
The Australian Centre for Construction Innovation, UNSW & Xypex Australia*

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1. INTRODUCTION

In accordance with Xypex Australia's ongoing commitment to research and development, further research has been undertaken to evaluate the impact of the addition of Xypex Admix C-Series (C-1000NF) on commercially batched concretes with a prescription of 435kg cementitious and a 0.40 water to cement ratio which reflects concrete utilized in areas where durability is a concern.

The concretes selected included supplementary cementitious materials (fly ash and slag) to represent concretes typically used in durable structures.

This abstract outlines the results of the investigation into the impact of the addition of Xypex Admix C-Series on water absorption, AVPV and water permeability of the concretes researched. This research was carried out by The Australian Centre for Construction Innovation (ACCI/UNSW). The results reported in this abstract include results obtained for **water absorption & AVPV** using AS1012.21, **water permeability test** (ACCI) and **RTA sorptivity test** (RTA T362).

2. MATERIALS

The three types of cement used were:

- A. AS3972 Type-GB with 25% fly ash (AS3582.1 or ASTM C618 Class F)
- B. AS3972 Type-GB slag blend with approximately 38% slag (AS3582.2)
- C. AS3972 Type-GB slag blend with approximately 60% slag (AS3582.2).

AS 1478.1 Type-WR (neutral set) admixture was added as required to target a slump of 80mm.

Xypex Admix C-Series which complies to AS1478.1 Special Purpose Admixture Type-SN, dosed at 0.8% or 1.2% in accordance with manufacturer's directions.

3 TEST RESULTS AND DISCUSSIONS

3.1 Water Absorption and AVPV Test (AS1012.21)

Table 3.1-A and 3.1-B summarizes the test results of samples of all concretes included in this investigation.

Table 3.1-A Summary of Water Absorption Test Results

Mix No	Immersion Water Absorption (%)			
	7 days in Limewater	Ratio to Control	56 days in Limewater	Ratio to Control
<i>Type-GB (25% Fly Ash)</i>				
2FA1	5.52	1.00	4.84	1.00
2FA2	5.33	0.97	4.66	0.96
2FA3	4.97	0.90	4.20	0.87
<i>Type-GB (38% Slag)</i>				
2LS1	4.82	1.00	4.18	1.00
2LS2	4.72	0.98	4.14	0.99
2LS3	4.59	0.95	3.94	0.94
<i>Type-GB (60% Slag)</i>				
2HS1	6.37	1.00	4.19	1.00
2HS2	6.16	0.97	4.19	1.00
2HS3	5.46	0.86	4.05	0.97

All concretes recorded lower water absorption values under continuous limewater curing to 56 compared to that under 7 days limewater curing followed by air curing to 56 days.

Table 3.1-B Summary of AVPV Test Results

Mix No	Apparent Volume of Permeable Voids – AVPV (%)				
	7 days Limewater	Ratio to Control	56 days Limewater	Ratio to Control	Reduction (%) for 56 days Curing in Limewater
<i>Type-GB (25% Fly Ash)</i>					
2FA1	12.86	1.00	11.29	1.00	- 12.2%
2FA2	12.32	0.96	11.04	0.98	- 10.4%
2FA3	11.43	0.89	9.78	0.87	- 14.4%
<i>Type-GB (38% Slag)</i>					
2LS1	11.24	1.00	10.92	1.00	- 2.9%
2LS2	10.95	0.97	9.58	0.88	- 12.5%
2LS3	10.81	0.96	9.39	0.86	- 13.1%
<i>Type-GB (60% Slag)</i>					
2HS1	12.80	1.00	9.93	1.00	- 22.4%
2HS2	12.74	1.00	9.69	0.98	- 24.0%
2HS3	12.48	0.98	9.37	0.94	- 25.0%

AVPV assessment to VicRoads Section 610 (Structural Concrete) is shown in Table 3.1-C. It is shown that maximum AVPV values at 28 days for VR440/40 test cylinders compacted by vibration is 13%. All concrete mixes shown in Table 3.1-B had AVPV values well below the requirements from VicRoads Section 610. However Xypex Admix C-Series modified concretes, 2FA3 and 2LS3, were tested and shown even further reduction in AVPV values compared to both control concretes by up to 14%.

Table 3.1-C VicRoads Section 610, Structural Concrete, VPV Requirements

Concrete Grade	Maximum VPV Values at 28 days (%)		
	Test Cylinders (compaction by vibration)	Test Cylinders (compacted by rodding)	Test Cores
VR330/32	14	15	17
VR440/40	13	14	16
VR450/50	12	13	15
VR470/55	11	12	14

3.2 Water Permeability Test (ACCI Method)

Table 3.2-A Water Permeability Coefficients

Mix No	Water Permeability Coefficient (m/s)	% Change to Control
<i>Type-GB (25% Fly Ash)</i>		
2FA1	2.664×10^{-12}	-
2FA2	7.871×10^{-13}	-70%
2FA3	1.834×10^{-13}	-93%
<i>Type-GB (38% Slag)</i>		
2LS1	Water penetration depth: 12.8mm	-
2LS2	Water penetration depth: 10.7mm	-14%
2LS3	Water penetration depth: 7.2mm	-44%
<i>Type-GB (60% Slag)</i>		
2HS1	1.008×10^{-11}	-
2HS2	1.648×10^{-11}	+63%
2HS3	6.167×10^{-12}	-39%

There were no signs of physical water transmission through any of sample of three Type-GB slag (38%) mixes under 100 meters water head. Because the water permeability in these 38% slag concretes was negligible under the testing pressure, water penetration depth in split concrete samples was measured at the end of water permeability tests using methylene blue

indicator as used in the RTA water sorptivity test.

3.3 RTA Water Sorptivity (RTA Test Method T362)

Table 3.3-A Summary of RTA Sorptivity Test Results

Mix No	RTA Sorptivity (mm) – <u>Exposure Classification C</u>	% Change to Control
<i>Type-GB (25% Fly Ash)</i>		
2FA1	24.8	-
2FA2	19.5	-21%
2FA3	17.6	-29%
<i>Type-GB (38% Slag)</i>		
2LS1	9.6	-
2LS2	8.9	-7%
2LS3	8.0	-17%
<i>Type-GB (60% Slag)</i>		
2HS1	12.1	-
2HS2	11.5	-5%
2HS3	10.7	-12%

Table 3.3-A summarizes the test results of sorptivity. As shown in the table, the Xypex Admix C-Series modified concrete mixes recorded lower water sorptivity depths compared to the control concretes for all the three types of concretes using Type-GB cements. The use of Xypex Admix C-Series was especially effective in the Type-GB 25% fly ash concretes and reduced the water sorptivity by 21% to 29%.

Table 3.3-B Durability Requirement for Concrete in RTA-B80

Exposure Classification	Minimum Cement Content (kg/m ³)	Maximum Water/Cement Ratio (By Mass)	Maximum Sorptivity Penetration Depth (mm)	
			Portland Cement	Blended Cement
A	320	0.56	35	35
B1	320	0.50	25	25
B2	370	0.46	17	20
C	420	0.40	N/A	8
U	In accordance with Annexure B80/A1			

Table 3.3-B reproduces the Table B80.6 in the RTA (NSW) QA Specification-B80 “Concrete Work for Bridges”, which specifies durability requirements based on water sorptivity results for concretes under various exposure conditions classified by AS3600. It is shown that the maximum sorptivity penetration depth is limited to 8mm for concrete applications in the exposure classification C. The concrete mixes in this research have not met this durability requirement except for the 1.2% Xypex Admix C-Series modified slag (38%) Mix-2LS3, which recorded an 8mm sorptivity depth, a 17% reduction from that of the control Mix-2LS1. It is not surprising that most of the concrete mixes of this investigation did not meet this strict requirement, because the “exposure classification C” includes the tidal and splash zones in marine environments and it is the most severe exposure classification according to AS3600. For concrete to be used in tidal and splash zones, the compressive strength grade usually needs to be 50MPa plus to achieve durability required for such severe exposure.

4. **CONCLUSIONS:**

Overall from the test results, concretes with the addition of Xypex Admix C-Series have demonstrated the following improvements:

1. For **Type-GB 25% fly ash cement concretes,** mixes modified with Xypex Admix C-Series have shown from modest to significant improvements in water penetration tests:
 - i.* Lower water absorption and AVPV by up to 13%;
 - ii.* Significantly lower sorptivity by up to 29%;
 - iii.* Significantly lower water permeability by 70% to 93% under 100m water head.

2. For **Type-GB cement concretes (using 38% slag),** concretes modified with Xypex Admix C-Series have shown modest to significant improvements in water penetration tests:
 - i.* Lower water absorption and AVPV by up to 13%;
 - ii.* Lower sorptivity by up to 17%;
 - iii.* Zero water penetration in water permeability tests under 100m water head and up to 44% lower water penetration depth.

3. For **Type-GB cement concrete (using 60% slag),** concretes modified with Xypex Admix C-Series have shown modest improvements in hardened state properties:
 - i.* Lower water absorption and AVPV;
 - ii.* Lower sorptivity by up to 12%;
 - iii.* Significantly lower water permeability by 39%.

It should be noted that absorption testing alone is not intended for use as an indicator or measure of durability. However, when combining the results of the three tests used in this document, it gives the reader an indication of how Xypex Admix C-Series improves the concrete matrix and therefore it is suitable for use in concrete for water tight construction.



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ANNEX A

PLASTIC AND HARDENED STATE PROPERTIES OF XYPEX ADMIX C-SERIES (C-1000NF) MODIFIED COMMERCIAL CONCRETES

Joint Research Project by

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1. INTRODUCTION

In accordance with Xypex Australia's ongoing commitment to research and development, further research has been undertaken to evaluate the impact of the addition of Xypex Admix C-Series (C-1000NF) on commercially batched concretes with a prescription of 435 Kg's cementitious and a 0.40 water to cement ratio which reflects concrete utilized in area where durability is a concern.

The concretes selected included supplementary cementitious materials (fly ash and slag) to represent concretes typically used in durable structures.

This abstract outlines the results of the plastic and hardened state properties of the concretes researched. This research was carried out by The Australian Centre for Construction Innovation (ACCI/UNSW). The properties reported in this abstract include **slump**, **setting time**, **compressive strength**, and **drying shrinkage**.

2. MATERIALS

The three types of cement used were:

- 2.1 AS3972 Type-GB with 25% fly ash (AS3582.1 or ASTM C618 Class F);
- 2.2 AS3972 Type-GB slag blend with approximately 38% slag (AS3582.2);
- 2.3 AS3972 Type-GB slag blend with approximately 60% slag (AS3582.2).

AS1478.1 Type-WR (neutral set) admixture was added as required to target a slump of 80mm. Xypex Admix C-Series which complies to AS1478.1 Special Purpose Admixture Type-SN, dosed at 0.8% or 1.2% in accordance with manufacturer's directions.

3. TEST RESULTS AND DISCUSSIONS

Test results are summarized and shown in Table 3-A.

Table 3-A Summary of Test Results

Mix Code	W/C Ratio	Cement Type and Content (kg)	Xypex Admix C-1000NF (% of Cement Content)	Slump (mm)	Setting Time	Compressive Strength			Drying Shrinkage
						3 days	28 days	91 days	
2FA1	0.40	25% FA (435)	Nil	95	Control	21.9	36.2	46.7	719
2FA2	0.40	25% FA (435)	0.8%	105	+ 2.2~2.5 hrs	22.1	44.1	53.8	577
2FA3	0.40	25% FA (435)	1.2%	100	+ 1.4~2.3 hrs	28.0	47.5	58.0	562
2LS1	0.40	38% Slag (435)	Nil	95	Control	28.1	49.9	64.8	814
2LS2	0.40	38% Slag (435)	0.8%	100	+ 2.2~2.7 hrs	28.6	52.7	65.7	689
2LS3	0.40	38% Slag (435)	1.2%	90	+ 4.0~4.1 hrs	28.6	52.9	66.3	711
2HS1	0.40	60% Slag (435)	Nil	100	Control	14.2	38.1	49.3	803
2HS2	0.40	60% Slag (435)	0.8%	125	+ 0.8~1.6 hrs	12.4	36.5	47.8	772
2HS3	0.40	60% Slag (435)	1.2%	95	+ 1.0~1.3 hrs	15.7	42.0	53.4	772

3.1 Slump (AS1012.3):

Compared to the control slumps were within the normally acceptable range with the exception being Mix-2HS2.

3.2 Setting Time (AS1012.18):

Xypex Admix C-Series modified concrete exhibited extensions in setting time when compared to the control. The results of Mix-2LS3 are inconsistent with the other results.

3.3 Compressive Strength (AS1012.9):

Overall, Xypex Admix C-Series concretes exhibited higher compressive strengths when compared to the controls with the exception of Mix-2HS2. All mixes at 91 days demonstrated continued strength gains.

➤ **Xypex Admix C-Series modified Type-GB (25% fly ash) concrete:**

At age of 28 days, mixes recorded up to 31% higher strengths than the control;

➤ **Xypex Admix C-Series modified Type-GB 38% slag concrete:**

At age of 28 days, compressive strengths showed an increase of 6% over the control;

➤ **Xypex Admix C-Series modified Type-GB 60% slag concrete:**

At age of 28 days, compressive strengths were higher than the control by up to 10%;

3.4 Drying Shrinkage (AS1012.13):

Drying shrinkage results of all Xypex C-Series treated mixes exhibited improved performance. In particular, results for the fly ash mixes showed significant reduction in shrinkage.

➤ **Xypex Admix C-Series modified Type-GB (25% fly ash) concrete:**

At 56 days, mixes recorded lower shrinkage of up to 22% compared to control.

➤ **Xypex Admix C-Series modified Type-GB 38% slag concrete:**

At 56 days, mixes recorded lower shrinkage of up to 15% compared to control.

➤ **Xypex Admix C-Series modified Type-GB 60% slag concrete:**

At 56 days, mixes recorded lower shrinkage of up to 4% compared to control.

4. CONCLUSIONS:

Test results confirm that Xypex Admix C-Series was compatible with both fly ash and slag blended cement concretes which also contained a typical neutral set water reducing admixture. Overall, Xypex Admix C-Series has demonstrated improvements with no adverse effects on general properties of concrete in both its plastic and hardened state. Results indicate improvement in both shrinkage and compressive strength may be achieved with Xypex Admix C-Series.