Coating Damp Concrete

Water Based, Solvent Based or Solvent Free

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Australasian Corrosion Association -
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PEERLESS Performance Resins & Composite Systems

Introduction

- 28 day cure before coating
  - Is the de facto industry Standard
  - Some consider this to be overly conservative
- Many waterborne coatings for concrete
  - Claimed to be suitable for wet and/or green concrete
- Anecdotal evidence that solvent containing or solvent free systems
  - May give better adhesion
- Performance under marginal conditions?
  - Surface water
  - Low temperatures

ACA Signs SSPC Licence Agreement

- "Following a successful trial of the SSPC Concrete Coating Inspection course earlier this year in Melbourne, the ACA has recently signed an agreement with SSPC to act as a licensee for this course in Australasia."
- "The objective of this course is to train individuals thoroughly in the proper methods of inspecting surface preparation and installation of protective coatings on concrete structures and facilities."
- "The SSPC Concrete Coating Inspection course will be added to the ACA 2016 course calendar.

Concrete Substrate

- "Capping Tiles" used
  - Manufactured by National Masonry (www.nationalmasonry.com.au)
  - From a standard masonry mix
  - Designed to achieve:
    15 MPa Characteristic Compressive Strength
- No load requirement
  - Therefore no specification for strength for this product

Concrete Mix Composition

- Known details
  - Quarried aggregate <30%
  - Sand <40%
  - Coal ash <30%
  - Portland cement <15%
  - Grade or Product Code: 5031

Concrete Surface Preparation

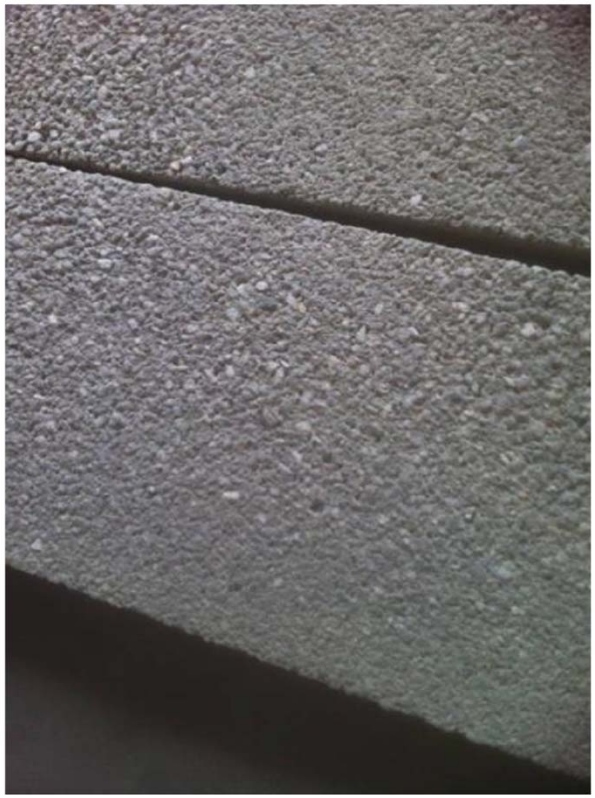
Three levels of “wetness”

- **Dry**
  - Concrete slabs left for at least 30 days in ambient air before coating
- **Wet**
  - Immersed in potable water
  - Then removed and coated
  - 30 minutes later
- **Damp**
  - Immersed in potable water
  - Then removed and coated
  - 90 minutes later

Water bath

Summary of Preparation Method

- Concrete slabs
  - 400 x 190 x 40 mm
- Abrasive blasted
  - Clean, rough surface
- Immersed in potable water
  - For more than 30 days
- Removed from water
  - Coated 30 & 90 minutes later
- Dry slabs as controls



Coating Systems

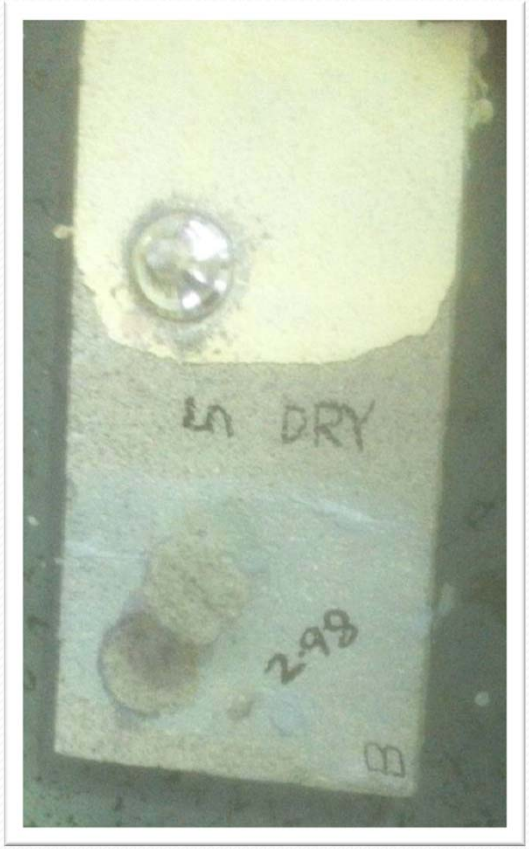
ID	Vehicle	Type	Comment
A	None	BisA based Epoxy + Amine	100% solids High Build Epoxy
B	None	Epoxy Novolac + Amine	100% solids High Build Novolac
C	Water	Polymer Epoxy Emulsion and Cement	Polymer Modified Cement Coating
D	MEK/Xylene	BisA based Epoxy + Amine	75% Solids High Build Epoxy
E	MEK/Xylene	Epoxy Novolac + Amine	75% Solids High Build Novolac
F	Water	BisA based Epoxy + Amine	Water dispersion – water added

Application

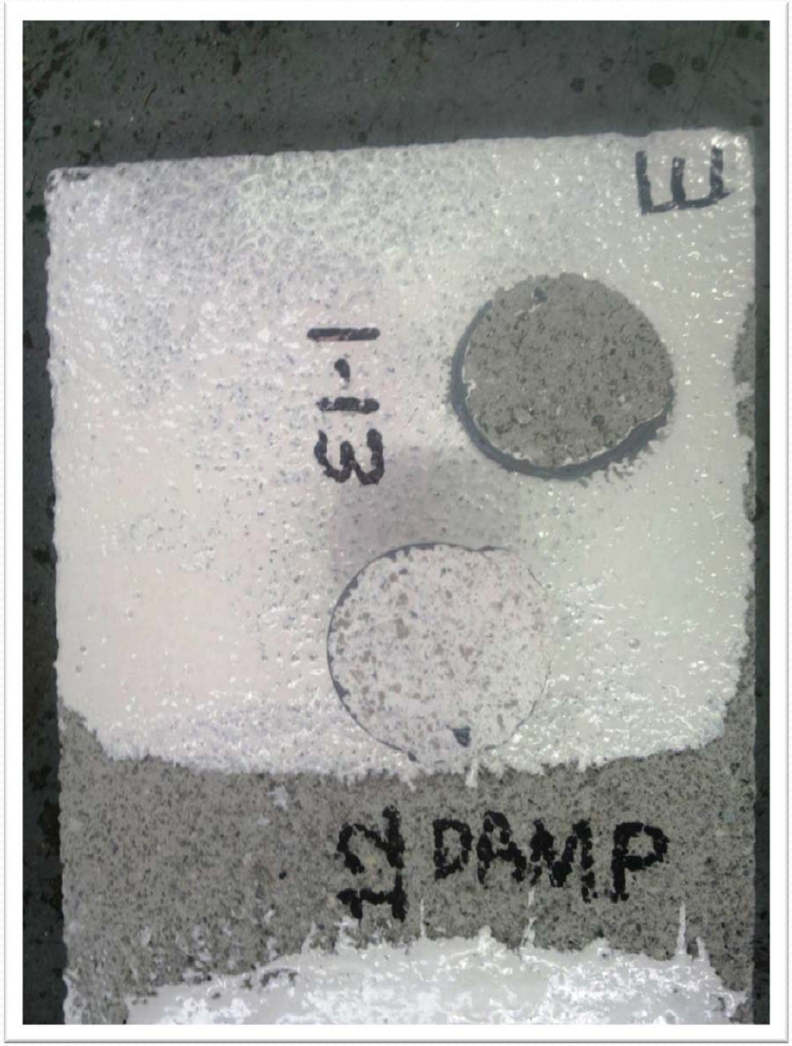
Adhesion Tests

- Pull off adhesion (MPa)
- “DeFelsko” “PosiTest” AT-A
- Coatings cured for at least one week
- 50 mm dollies
  - Maximum value 3.30 MPa
- 0.12 MPa per second
  - Commonly used rate for concrete coatings
- Duplicate results
- Failure mode/s (and percentages) determined

Adhesion Tests



Adhesion Tests



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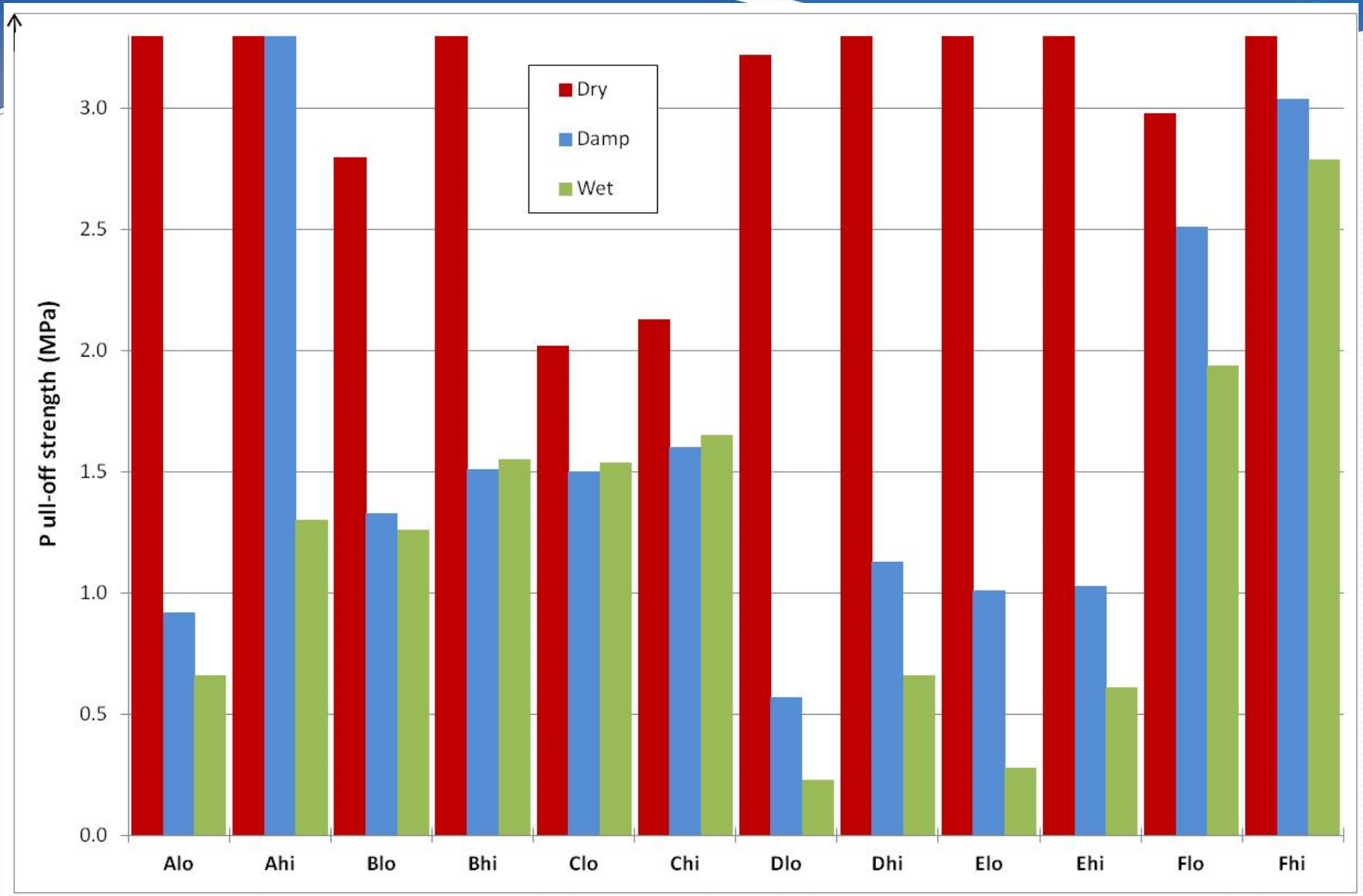
Dry
Damp
Wet
P ull-off strength (MPa)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Alo
Ahi
Blo
Bhi
Clo
Chi
Dlo
Dhi
Elo
Ehi
Flo
Fhi

Results on dry slabs

ID	Vehicle	Type	Pull-off adhesion values (MPa)		Failure modes		Average value (MPa)
			Low	High	Low	High	
A	None	BisA based Epoxy + Amine	>3.30	>3.30	100% Cc	100% G	>3.3
B	None	Epoxy Novolac + Amine	2.80	>3.30	100% Cc	100% Cc	≥3
C	Water	Polymer Epoxy Emulsion + Cement	2.02	2.13	100% Cc	80% Ct 20% Cc	2.1
D	MEK/ Xylene	BisA based Epoxy + Amine	3.22	>3.30	70% Cc 30% G	100% G	≥3
E	MEK/ Xylene	Epoxy Novolac + Amine	>3.30	>3.30	80% G 20% Cc	100% Cc	>3.3
F	Water	BisA based Epoxy + Amine	2.98	>3.30	100% Cc	100% Cc	≥3

Results on dry slabs

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			Low	High	Low	High	
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B	None	Epoxy Novolac + Amine	2.80	>3.30	100% Cc	100% Cc	≥3
C	Water	Polymer Epoxy Emulsion + Cement	2.02	2.13	100% Cc	80% Ct 20% Cc	2.1
D	MEK/ Xylene	BisA based Epoxy + Amine	3.22	>3.30	70% Cc 30% G	100% G	≥3
E	MEK/ Xylene	Epoxy Novolac + Amine	>3.30	>3.30	80% G 20% Cc	100% Cc	>3.3
F	Water	BisA based Epoxy + Amine	2.98	>3.30	100% Cc	100% Cc	≥3

A Adhesive failure between the coating & the concrete
Cc Cohesive failure in the concrete
Ct Cohesive failure in the coating
G Failure between the adhesive and the coating (glue failure)

Results on dry slabs

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D	MEK/ Xylene	BisA based Epoxy + Amine	3.22	>3.30	70% Cc 30% G	100% G	≥3
E	MEK/ Xylene	Epoxy Novolac + Amine	>3.30	>3.30	80% G 20% Cc	100% Cc	>3.3
F	Water	BisA based Epoxy + Amine	2.98	>3.30	100% Cc	100% Cc	≥3

Polymer epoxy emulsion cement 1 MPa lower (or more)

A Adhesive failure between the coating & the concrete
Ct Cohesive failure in the coating
Cc Cohesive failure in the concrete
G Failure between the adhesive and the coating (glue failure)

Results on Damp slabs

ID	Vehicle	Type	Pull-off adhesion values (MPa)		Failure modes		Average value (MPa)
			Low	High	Low	High	
A	None	BisA based Epoxy + Amine	0.92	>3.30	35% A 60% G 5% Cc	70% A 30% Cc	≥1
B	None	Epoxy Novolac + Amine	1.33	1.51	100% G	20% A 80% G	1.4
C	Water	Polymer Epoxy Emulsion + Cement	1.50	1.60	70% Ct 30% G	90% Ct 10% Cc	1.6
D	MEK/ Xylene	BisA based Epoxy + Amine	0.57	1.13	90 % A 5 % Cc 5% G	80% A 20% Cc	0.9
E	MEK/ Xylene	Epoxy Novolac + Amine	1.01	1.03	90 % A 5 % Cc 5% G	80% A 20% Cc	1.0
F	**Water**	BisA based Epoxy + Amine	2.51	3.04	100% Cc	100% Cc	2.8

Spurious result

A Adhesive failure between the coating & the concrete
Ct Cohesive failure in the coating
Cc Cohesive failure in the concrete
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A	None	BisA based Epoxy + Amine	0.92	>3.30	35% A 60% G 5% Cc	70% A 30% Cc	≥1
B	None	Epoxy Novolac + Amine	1.33	1.51	100% G	20% A 80% G	1.4
C	Water	Polymer Epoxy Emulsion + Cement	1.50	1.60	70% Ct 30% G	90% Ct 10% Cc	1.6
D	MEK/ Xylene	BisA based Epoxy + Amine	0.57	1.13	90 % A 5 % Cc 5% G	80% A 20% Cc	0.9
E	MEK/ Xylene	Epoxy Novolac + Amine	1.01	1.03	90 % A 5 % Cc 5% G	80% A 20% Cc	1.0
F	**Water**	BisA based Epoxy + Amine	2.51	3.04	100% Cc	100% Cc	2.8

Inconsistent results of a solvent free system

A Adhesive failure between the coating & the concrete
Ct Cohesive failure in the coating
Cc Cohesive failure in the concrete
G Failure between the adhesive and the coating (glue failure)

Results on wet slabs

ID	Vehicle	Type	Pull-off adhesion values (MPa)		Failure modes		Average value (MPa)
			Low	High	Low	High	
A	None	BisA based Epoxy + Amine	0.66	1.30	90% A 10% Cc	80% A 5% Cc 15% G	1.0
B	None	Epoxy Novolac + Amine	1.26	1.55	100% G	65% A 5% Cc 30% G	1.4
C	Water	Polymer Epoxy Emulsion + Cement	1.54	1.65	60% Ct 40% Cc	100% Ct	1.6
D	MEK/ Xylene	BisA based Epoxy + Amine	0.23	0.66	90% A 10% Cc	95% A 5% Cc	0.4
E	MEK/ Xylene	Epoxy Novolac + Amine	0.28	0.61	90% A 10% Cc	95% A 5% Cc	0.4
F	Water	BisA based Epoxy + Amine	1.94	2.79	100% Cc	100% Cc	**2.4**

A Adhesive failure between the coating & the concrete
Ct Cohesive failure in the coating
Cc Cohesive failure in the concrete
G Failure between the adhesive and the coating (glue failure)

Spurious result: Incomplete coating cover means adhesion directly to concrete occurs

PEERLESS Performance Resins & Composite Systems

Results on wet slabs

ID	Vehicle	Type	Pull-off adhesion values (MPa)		Failure modes		Average value (MPa)
			Low	High	Low	High	
A	None	BisA based Epoxy + Amine	0.66	1.30	90% A 10% Cc	80% A 5% Cc 15% G	1.0
B	None	Epoxy Novolac + Amine	1.26	1.55	100% G	65% A 5% Cc 30% G	1.4
C	Water	Polymer Epoxy Emulsion + Cement	1.54	1.65	60% Ct 40% Cc	100% Ct	1.6
D	MEK/ Xylene	BisA based Epoxy + Amine	0.23	0.66	90% A 10% Cc	95% A 5% Cc	0.4
E	MEK/ Xylene	Epoxy Novolac + Amine	0.28	0.61	90% A 10% Cc	95% A 5% Cc	0.4

Poor adhesion of solvent borne systems

A Adhesive failure between the coating & the concrete
Ct Cohesive failure in the coating
Cc Cohesive failure in the concrete
G Failure between the adhesive and the coating (glue failure)

Pull off adhesion results Epoxies on Concrete

50mm diameter dollies glued to epoxies with Epigen 907
Glue applied: 13/6/15. Tested 16/6/15 **Positest AT 0.12 MPa/s**

Cc = Substrate failure
A = Adhesive failure
Ct = Coating cohesive failure
G = Dolly adhesive failure

Slab	Concrete condition	NEW ID	Epoxy system	Pull-off Mpa	Average	Failure Mode Cc	A	Ct	G
3	Dry	A	100% solids High Build Epoxy	3.30	3.30	100			
				3.30					100
	Dry	B	100% solids High Build Novolac	3.30	3.05	100			
				2.80		100			
	Dry	C	Polymer Modified Cement Coating	2.13	2.08	20		80	
				2.02		100			
	Dry	D	75% solids High Build Epoxy	3.22	3.26	70			30
				3.30					100
	Dry	E	75% solids High Build Novolac	3.30	3.30	20			80
				3.30		100			
	Dry	F	Water dispersion – water added	3.30	3.14	100			
				2.98		100			
	Damp	A	100% solids High Build Epoxy	0.92	3.04	5	35		60
				3.30		30	70		
	Damp	B	100% solids High Build Novolac	1.51	1.42		20		80
				1.33					100
	Damp	C	Polymer Modified Cement Coating	1.60	1.55	10		90	
				1.50				70	30
	Damp	D	75% solids High Build Epoxy	0.57	0.85	5	90		5
				1.13		20	80		
	Damp	E	75% solids High Build Novolac	1.01	1.02	5	90		5
				1.03		20	80		
11	Damp	F	Water dispersion – water added	2.51	2.78	100			
				3.04		100			
	Wet	A	100% solids High Build Epoxy	1.30	0.98	5	80		15
				0.66		10	90		
	Wet	B	100% solids High Build Novolac	1.55	1.41	5	65		30
				1.26					100
	Wet	C	Polymer Modified Cement Coating	1.54	1.60	40		60	
				1.65				100	
	Wet	D	75% solids High Build Epoxy	0.66	0.45	5	95		
				0.23		10	90		
	Wet	E	75% solids High Build Novolac	0.61	0.45	5	95		
				0.28		10	90		
	Wet	F	Water dispersion – water added	1.94	2.37	100			
17				2.79		100			

OLD

A	Polymer Modified Cement Coating
B	Water Dispersion
C	100% solids High Build Epoxy
D	100% solids High Build Novolac
E	75% solids High Build Epoxy
F	75% solids High Build Novolac

Solvent: Xylene/MEK

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	Slab	Concrete condition	NEW ID	Epoxy system	Pull-off Mpa	Average	Failure Mode Cc	A	Ct	G
Dry	3	Dry	A	100% solids High Build Epoxy	3.30	3.30	100			
					3.30					100
		Dry	B	100% solids High Build Novolac	3.30	3.05	100			
					2.80		100			
		Dry	C	Polymer Modified Cement Coating	2.13	2.08	20		80	
					2.02		100			
		Dry	D	75% solids High Build Epoxy	3.22	3.26	70			30
					3.30					100
		Dry	E	75% solids High Build Novolac	3.30	3.30	20			80
					3.30		100			
		Dry	F	Water dispersion – water added	3.30	3.14	100			
					2.98		100			
Damp		Damp	A	100% solids High Build Epoxy	0.92	3.04	5	35		60
					3.30		30	70		
		Damp	B	100% solids High Build Novolac	1.51	1.42		20		80
					1.33					100
		Damp	C	Polymer Modified Cement Coating	1.60	1.55	10		90	
					1.50				70	30
		Damp	D	75% solids High Build Epoxy	0.57	0.85	5	90		5
					1.13		20	80		
		Damp	E	75% solids High Build Novolac	1.01	1.02	5	90		5
					1.03		20	80		
		Damp	F	Water dispersion – water added	2.51	2.78	100			
	11				3.04		100			
Wet		Wet	A	100% solids High Build Epoxy	1.30	0.98	5	80		15
					0.66		10	90		
		Wet	B	100% solids High Build Novolac	1.55	1.41	5	65		30
					1.26					100
		Wet	C	Polymer Modified Cement Coating	1.54	1.60	40		60	
					1.65				100	
		Wet	D	75% solids High Build Epoxy	0.66	0.45	5	95		
					0.23		10	90		
		Wet	E	75% solids High Build Novolac	0.61	0.45	5	95		
					0.28		10	90		
		Wet	F	Water dispersion – water added	1.94	2.37	100			
	17				2.79		100			

Substrate failure primarily

OLD

A	Polymer Modified Cement Coating
B	Water Dispersion
C	100% solids High Build Epoxy
D	100% solids High Build Novolac
E	75% solids High Build Epoxy
F	75% solids High Build Novolac

Solvent: Xylene/MEK

PEERLESS Performance Resins & Composite Systems

Pull off adhesion results Epoxies on Concrete

50mm diameter dollies glued to epoxies with Epigen 907
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Cc = Substrate failure
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G = Dolly adhesive failure

	Slab	Concrete condition	NEW ID	Epoxy system	Pull-off Mpa	Average	Failure Mode Cc	A	Ct	G
Dry	3	Dry	A	100% solids High Build Epoxy	3.30	3.30	100			
					3.30					100
		Dry	B	100% solids High Build Novolac	3.30	3.05	100			
					2.80		100			
		Dry	C	Polymer Modified Cement Coating	2.13	2.08	20		80	
					2.02		100			
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					3.30					100
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					3.30		30	70		
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					1.50				70	30
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	17				2.79		100			

Substrate failure primarily

Polymer cement: 80% cohesive failure

OLD

A	Polymer Modified Cement Coating
B	Water Dispersion
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Dry

Damp

Wet

Substrate failure primarily

Polymer cement: 80% cohesive failure

Polymer cement: 80% cohesive failure

OLD
A Polymer Modified Cement Coating
B Water Dispersion
C 100% solids High Build Epoxy
D 100% [illegible]
E 75% s
F 75% s

Solvent: Xylene/[illegible]

PEERLESS Performance Resins & Composite Systems

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	Dry	B	100% solids High Build Novolac	3.30	3.05	100			
				2.80		100			
	Dry	C	Polymer Modified Cement Coating	2.13	2.08	20		80	
				2.02		100			
	Dry	D	75% solids High Build Epoxy	3.22	3.26	70			30
				3.30					100
	Dry	E	75% solids High Build Novolac	3.30	3.30	20			80
				3.30		100			
	Dry	F	Water dispersion – water added	3.30	3.14	100			
				2.98		100			
	Damp	A	100% solids High Build Epoxy	0.92	3.04	5	35		60
				3.30		30	70		
	Damp	B	100% solids High Build Novolac	1.51	1.42		20		80
				1.33					100
	Damp	C	Polymer Modified Cement Coating	1.60	1.55	10		90	
				1.50				70	30
	Damp	D	75% solids High Build Epoxy	0.57	0.85	5	90		5
				1.13		20	80		
	Damp	E	75% solids High Build Novolac	1.01	1.02	5	90		5
				1.03		20	80		
11	Damp	F	Water dispersion – water added	2.51	2.78	100			
				3.04		100			
	Wet	A	100% solids High Build Epoxy	1.30	0.98	5	80		15
				0.66		10	90		
	Wet	B	100% solids High Build Novolac	1.55	1.41	5	65		30
				1.26					100
	Wet	C	Polymer Modified Cement Coating	1.54	1.60	40		60	
				1.65				100	
	Wet	D	75% solids High Build Epoxy	0.66	0.45	5	95		
				0.23		10	90		
	Wet	E	75% solids High Build Novolac	0.61	0.45	5	95		
				0.28		10	90		
	Wet	F	Water dispersion – water added	1.94	2.37	100			
17				2.79		100			

Dry

Damp

Wet

Substrate failure primarily

Polymer cement: 80% cohesive failure

OLD
A Polymer Modified Cement Coating
B Water Dispersion
C 100% solids High Build Epoxy
D 100% [illegible]
E 75% s
F 75% s

Solvent: Xylene/[illegible]

Polymer cement: 80% cohesive failure

Solvent borne: >90% adhesive failure

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Photo Record

Polymer modified cement to **dry** concrete.

Top: Solvent containing epoxy novolac.
Bottom: Water dispersed system.

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Photo Record

Water dispersed system (with added water) to **dry** concrete.

Solvent based standard epoxy to **dry** concrete.

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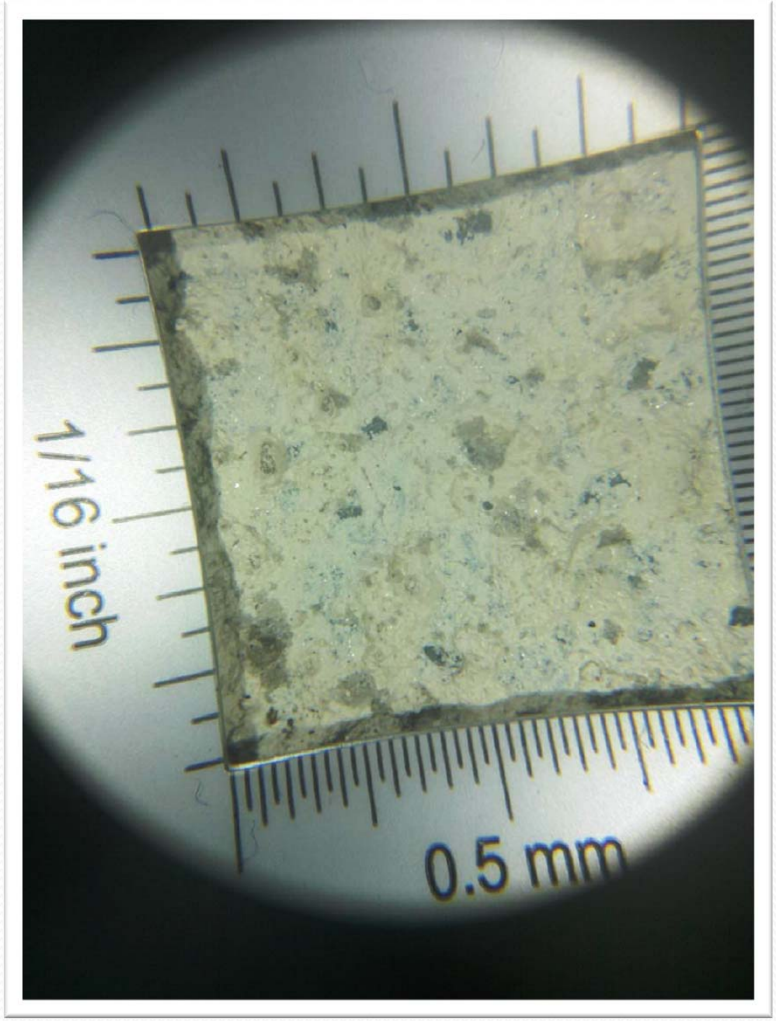
Photo Record

Solvent based standard epoxy to **wet** concrete



X10 Magnification

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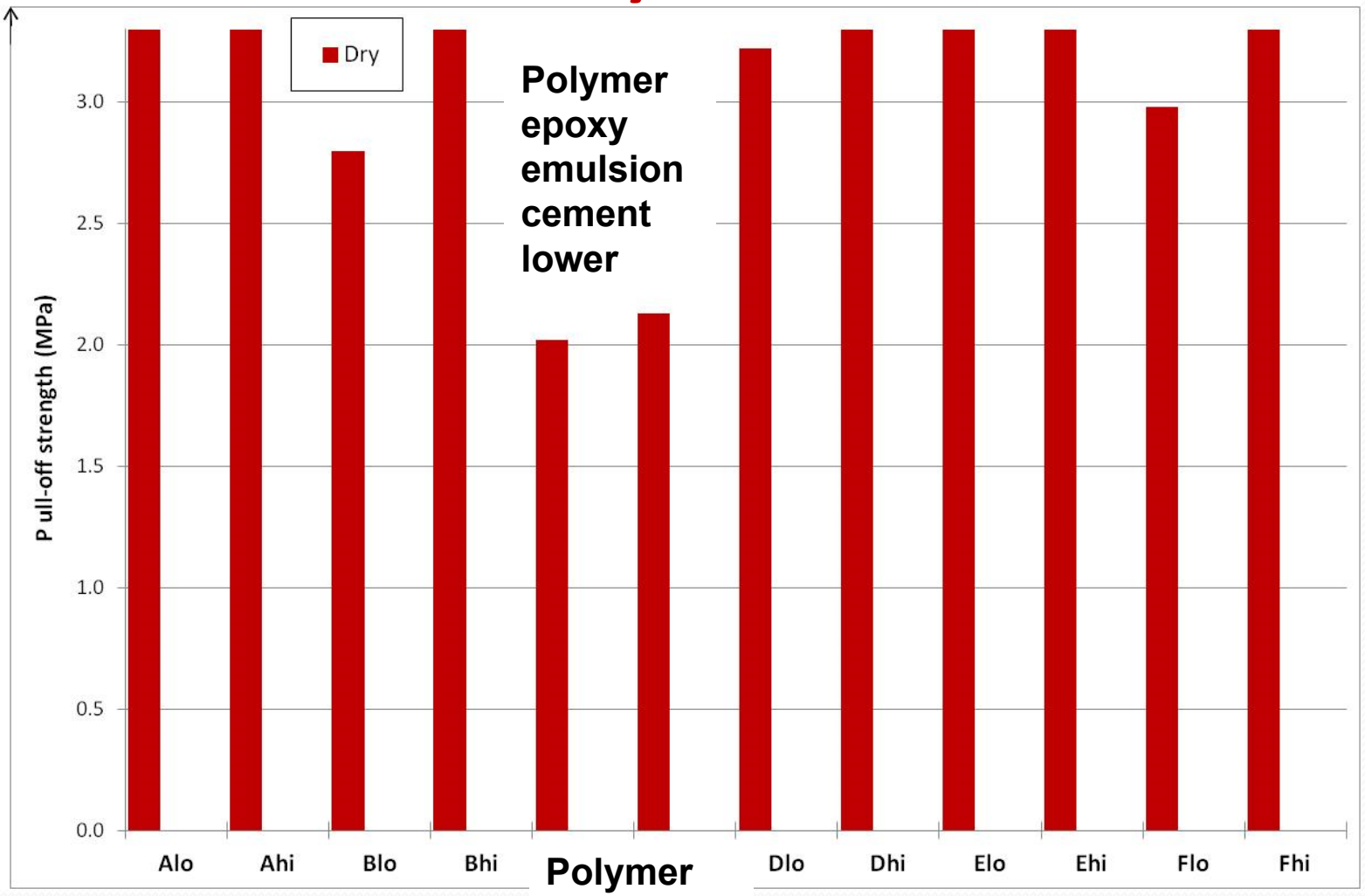
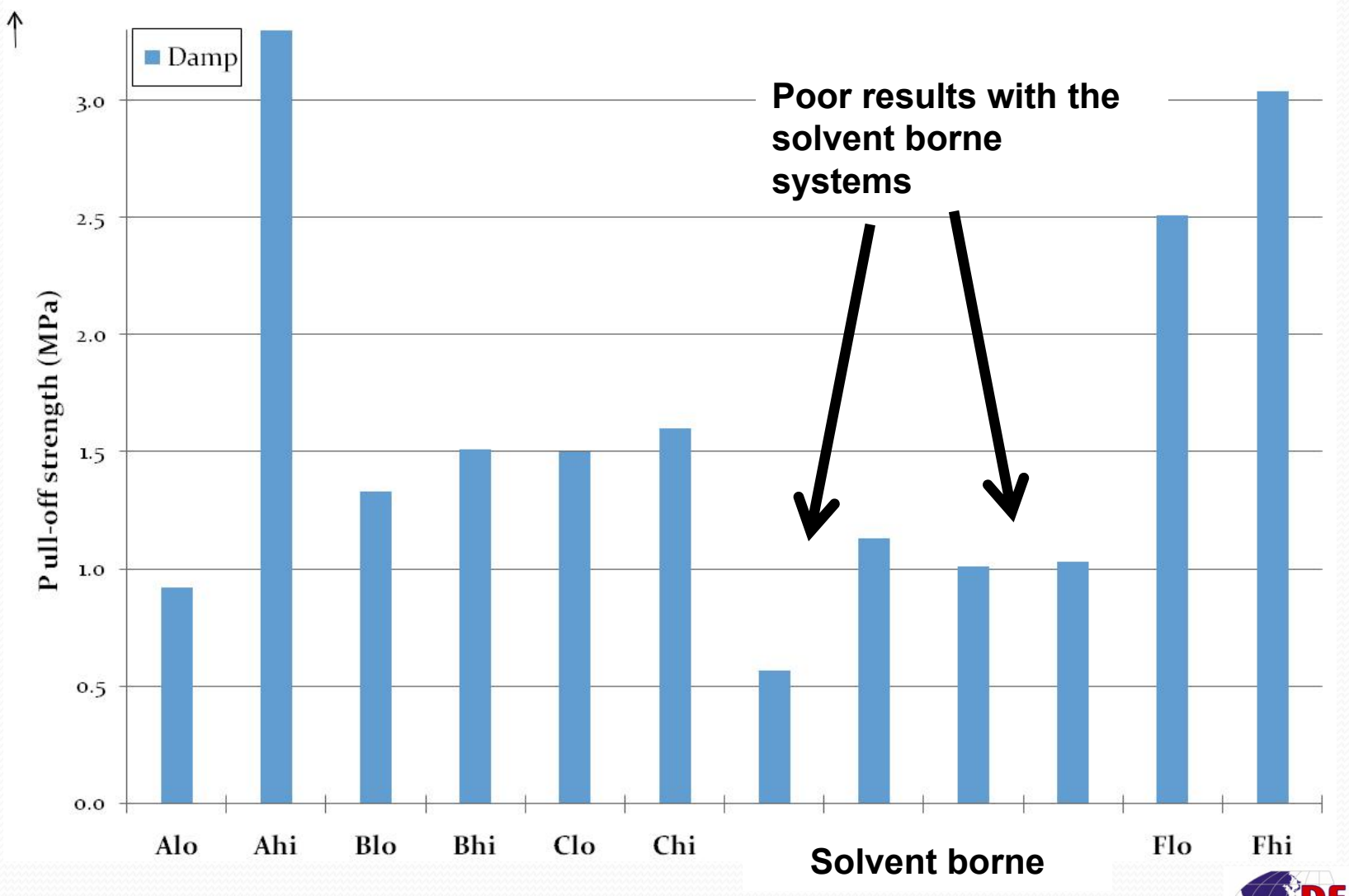
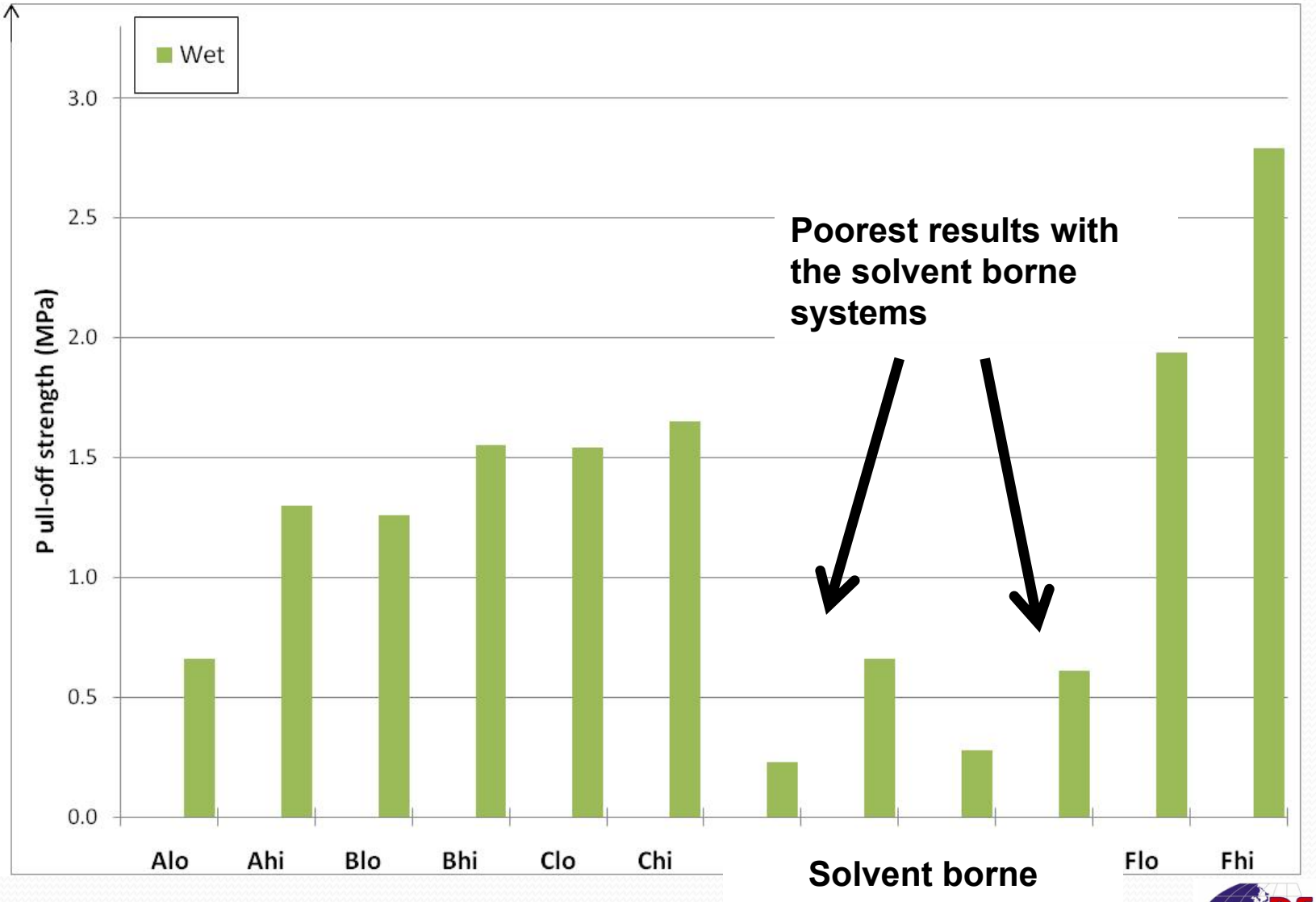
Results on dry slabs



Results on Damp slabs



Results on wet slabs



Observations

- **Coatings containing solvent** demonstrate reduced adhesion to concrete that has water present, the more water the worse the adhesion.

- **Solventless** coatings do adhere to wet concrete but the improvement in adhesion increases very quickly with drying or drainage time – would have been very interested to see results had 2 to 3 hours after removal from water.

Observations

- The **water dispersed system** (with water added) is not practical to use as a barrier coating, did show increased adhesion values but not conclusive in relation to the mechanisms and relationships (the concrete substrate was not completely covered by the coating).

- The **polymer cement** also had poor cohesive strength when applied to damp or wet concrete and the integrity as a whole is questionable.

Next Steps

- This work provides sufficient interest to undertake further evaluation into the adhesion on concrete that is:
  - Over-coated hours and days after withdrawing from water:
  - 24, 48, 72 hours old = actual green (preparation?)
  - Other concrete ages
- An investigation into the effect of Moisture Vapour Transmission (MVT) through concrete is warranted
  - **Using slabs that are standing in water with the top surface exposed to air, rather than draining under positive MVT load**

Acknowledgements

- Sally Nugent of Salyent – for format & test inputs, and critique

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Thank you

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