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ELASTOMERIC CANAL SEALANTS

APPLICATION TO WET CONCRETE

DRY-DAMP-UNDERWATER STUDY

December 1993

U.S. DEPARTMENT OF THE INTERIOR
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16. ABSTRACT

The Bureau of Reclamation performed laboratory testing to identify elastomeric canal sealants suitable for application to wet concrete, including underwater application to concrete. The report recommends several sealants for use underwater and in damp conditions. Future field studies will use the sealants identified in this study to further evaluate the areas of surface preparation, application equipment, and application techniques.

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UNITED STATES DEPARTMENT OF THE INTERIOR ★ BUREAU OF RECLAMATION

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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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INTRODUCTION

Elastomeric joint sealants normally are applied to dry concrete. Product literature typically states that concrete must be clean, dry, and fully cured. Proper surface preparation is critical, and sandblasting is typically recommended. However, for both new construction and remedial work, joint sealants are sometimes needed that can be applied in damp-wet conditions, or even underwater.

For new construction, the normal procedure is to place the concrete, form the joints, apply curing compound, cure 28 days, sandblast, airblast, apply sealant, cure 1 to 7 days, and place into service. However, short construction windows do not always allow this much time. Therefore, sealants are needed that can be applied to fresh, green concrete.

For remedial or maintenance work, the normal procedure is to drain the canal (or other concrete structure), dry-out the joints, sandblast, airblast, apply sealant, cure 1 to 7 days, and return to service. Sometimes the canal cannot be dewatered; other times it cannot be dried out sufficiently. Therefore, sealants are needed that can be installed underwater or in damp-wet conditions.

In 1988, the Lower Colorado Dive Team, working on the CAP (Central Arizona Project) experimented with sealing concrete joints underwater. Problems with surface preparation, material selection, application techniques and application equipment hindered their efforts. Surface preparation was minimal and consisted of manually brushing debris from the joint. The materials evaluated included a chemical grout, an asphalt tar, an epoxy, a froth polyurethane foam, common plumber's putty, an elastomeric sealant (caulk), and cement grout. The elastomeric sealant seemed to work best, but chemical grout and froth foam also showed promise. Some of the materials had a lower specific gravity than water and tended to float out of the joint (fig. 1). Other materials tended to bond better to the application equipment and divers than to the concrete. The materials were applied using caulking guns, syringes, plastic baggies, putty knives, and fingers. Syringes seemed to work best, except they were generally small and did not hold much material. Caulking guns also worked well, except the paper caulking tubes tended to deteriorate when underwater for extended periods. Finally, the bond, movement capability, and durability of the installed joint materials were identified as concerns which needed further evaluation (fig. 2).

This study was designed to identify elastomeric canal sealants suitable for installation in damp-wet conditions and even underwater. Surface preparation, application techniques, and application equipment were also addressed. Other sealant materials (such as chemical grouts and rapid-set concretes) were not evaluated in this study. The chemical grouts are known to be effective in sealing leaks in wet conditions; however, they are quite expensive and require specialized application equipment. Rapid-set concretes can be effective and economical, but cannot accommodate continued joint movement.

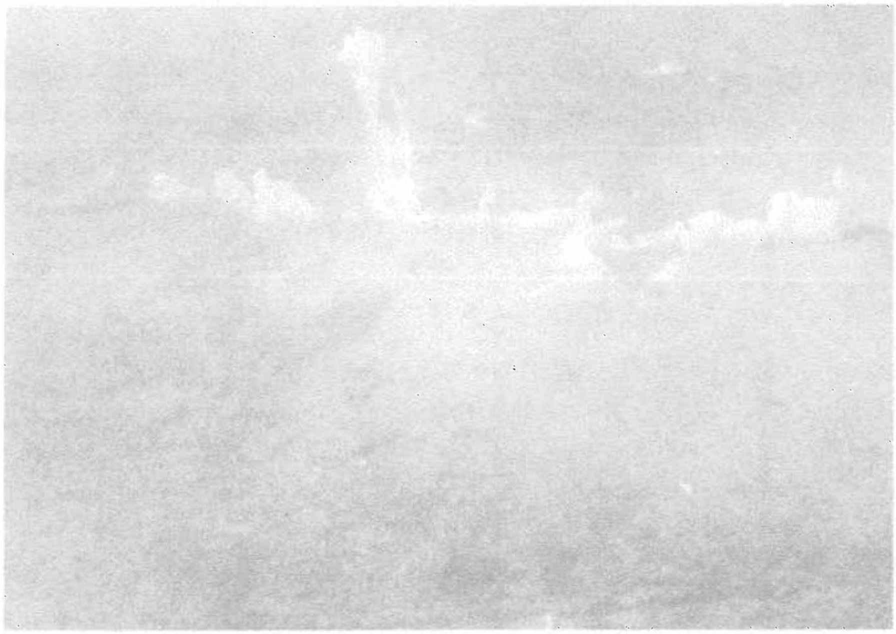

Figure 1. - Froth foam tends to float out of the joint as it has a specific gravity less than water (CAP photo).

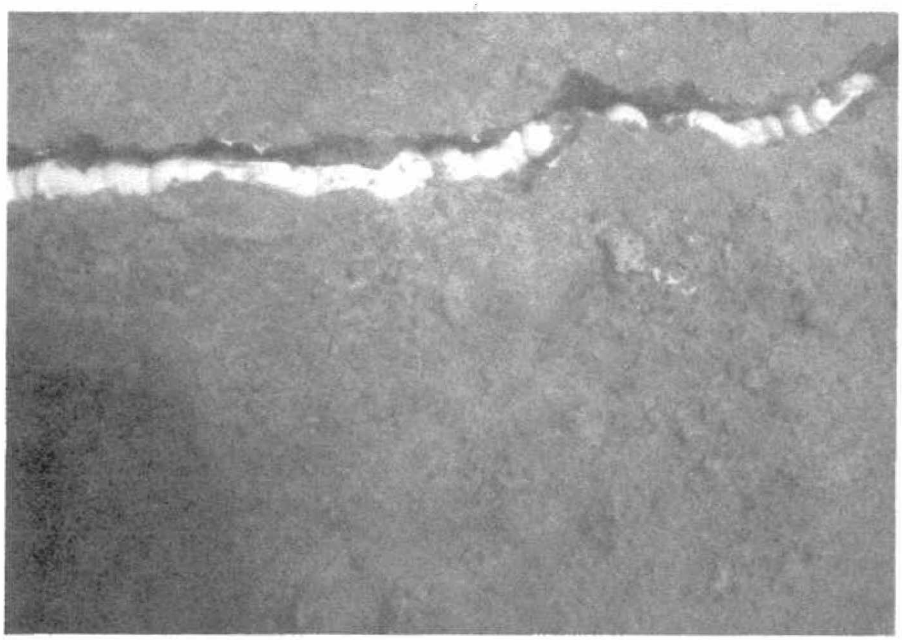

Figure 2. - Elastomeric caulk has filled this joint; however, bond, movement capability, and durability are unknown (CAP photo).

CONCLUSIONS

Sealants for underwater application to concrete. - Four sealants were identified which performed well when applied underwater. These sealants bonded to the concrete and withstood periodic 50 percent joint movement for up to 26 weeks. Refer to the Recommendations section for further information specific to each sealant material.

Sealant	Score
Sikaflex 1A	10
Burke U-Seal 3200	10
Bostik 915	9
Bostik 1000	7

Sealants for application to damp-wet concrete. - Twelve sealants were identified which performed well when applied to damp-wet concrete. Again, these sealants bonded to the concrete and withstood periodic 50 percent joint movement for up to 26 weeks. Refer to the Recommendations section for further information specific to each sealant material.

Sealant	Score
Sikaflex 1A	10
Bostik 915	10
Sikaflex 2C	10
Koch 9015	10
Burke U-Seal 3200	10
Vulkem 116	8
Koch 9028	6½
Bostik 1000	6
Vulkem 202	6
Dow 888	6
PRC 7000	6
Dynatrol I	5½

Aquatapoxy and Aquatapoxy Flex. - These epoxies are specifically intended for underwater application to concrete and may prove less susceptible to surface preparation problems than other sealant materials. They scored poorly in this study because of their small movement capability. However, Aquatapoxy Flex can accommodate 5 to 15 percent elongation and may prove useful for applications where small joint movement is expected.

Underwater application equipment and techniques. - The most effective application equipment was a caulking gun. One-part sealants were usually supplied in either paper or plastic caulking cartridges. The paper caulking cartridges must be used quickly as they have a limited application window underwater. Two-part sealants were mixed in the dry, and then loaded into a caulking gun or syringe for application. The sealants did not readily bond to the wet concrete, and extensive tooling (working with a putty knife) was required to remove trapped water and ensure intimate contact with the concrete. But once installed and cured, several sealants demonstrated good bond and movement capability.

Application to damp-wet concrete. - Application was similar to application in the dry. Some additional tooling was required to ensure intimate contact with concrete, but not as much as with the underwater application.

Surface preparation. - All concrete surfaces were ground (No. 50 grit) prior to sealant application; grinding produces a surface profile similar to sandblasting. For field application in damp-wet conditions, sandblasting is recommended. Underwater surface preparation needs further study, but might include high-pressure water jets, or water jets with sand injectors.

Future field studies. - Future field installations either in damp-wet conditions or underwater will experiment with the sealants identified in this study. Important factors that still need evaluation are ease of application, application equipment and techniques, sensitivity to surface preparation, effect of waterflow (currents), and vapor pressure gradients.

Primers. - Primers were not evaluated in this study. Manufacturers often recommend primers for damp-wet conditions. However, a previous Reclamation study (Report No. R-93-09, May 1993) found primers to be of little or no value. The current study found that satisfactory results can be obtained even underwater without primers. Advantages of primers is another subject for future study.

PROCEDURE

Preparation. - Laboratory specimens were prepared under three conditions: **Dry** - the control group applied to clean dry concrete; **Damp** - applied to damp-wet concrete; **Underwater** - applied underwater. After curing, all samples were tested for ultimate mechanical properties, and for modulus of elasticity at 25- and 50-percent elongation over a 26-week period. Sixteen sealants were included in this study. Sealant selection was based on performance in the Air-Water-Heat Study (Report No. R-93-09, May 1993) where sealants were applied to dry concrete and tested for modulus of elasticity over a 4-year period. The following 16 materials were evaluated in this study:

Aquatapoxy	Koch 9028
Aquatapoxy Flex	Mameco Vulkem 116
Bostik 915	Mameco Vulkem 202
Bostik 1000	Pecora Dynatrol 1
Burke U-Seal 3200	PRC 7000
Dow 795	Sikaflex 1A
Dow 888	Sikaflex 2C
Koch 9015	Sonneborne NP-2

Test Specimens. - Modulus specimens were prepared per ASTM C719 (modified), "Standard Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants under Cyclic Movement (Hockman cycle)." Uncured sealant was troweled into place between freshly ground concrete blocks to form a 1/2- x 1/2- x 2-inch sealant bead as shown on figure 3. A total of 12 specimens were prepared for each sealant. Four on **Dry** concrete (control), four on **Damp** concrete, and four on **Underwater** concrete.

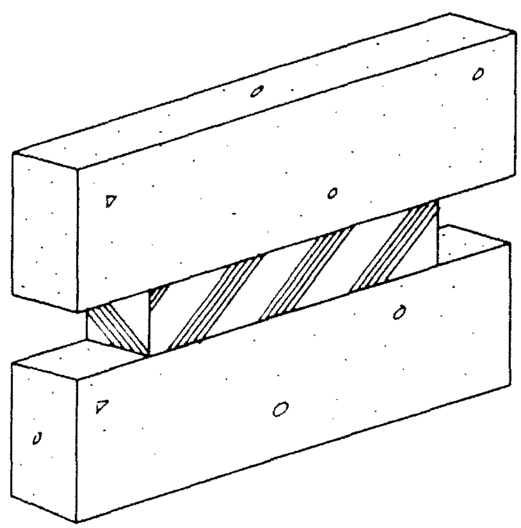

Figure 3. - Modulus test specimen per ASTM C719.

Application. - For the damp specimens, the concrete blocks were submerged in water for 5 to 10 minutes. The blocks were allowed to drip-dry for 1 minute prior to sealant application. For the underwater specimens, the concrete blocks were again submerged in water for 5 to 10 minutes. The sealant was then applied underwater. Some of the two-part sealant manufacturers provided mix ratios (by weight) for their products. In these cases, the sealant was mixed a pint at a time. The mix ratio was carefully controlled by weighing each component. If the weight mix ratio was not known, the entire sample (usually one gallon) was mixed per the manufacturer's instructions. Once mixed, the two-part sealants were loaded into a small caulking gun or syringe (fig. 4) for application (fig. 5). All of the one-part sealants were supplied in caulking cartridges. The sealant did not readily stick to the submerged concrete; therefore, extensive tooling was required to remove trapped water and ensure intimate contact with the concrete (fig. 6). The damp specimens also required a little extra tooling, but not nearly as much as the underwater specimens.

Curing. - The underwater specimens were cured underwater, while the dry and damp specimens were cured in air. Cure time was 2 to 6 weeks for the two-part sealants, and 4 to 7 weeks for the one-part sealants.

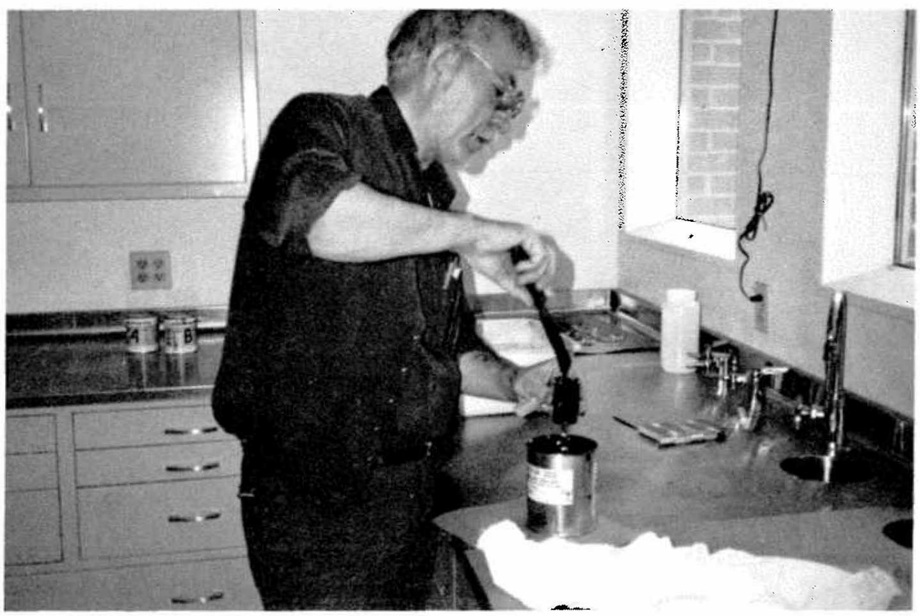

Figure 4. - After mixing, two-part sealants were loaded into a syringe or small caulking gun.

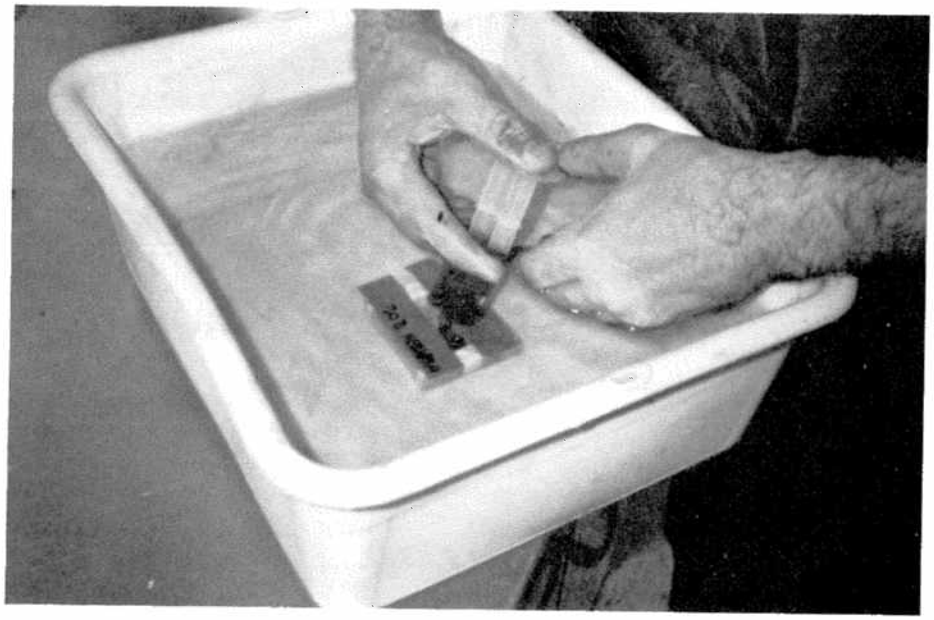

Figure 5. - Use of the caulking gun or syringe simplified under water installation.

Figure 6. - Extensive tooling of the underwater specimens was needed to remove trapped water pockets, and promote good bond.

Testing. - After curing, half the sealant specimens were destructively tested for ultimate tensile strength and elongation. The results are summarized in table 1a. The tensile and elongation properties of the Damp and Underwater specimens are presented as a percentage of the "Dry" values in table 1b.

Table 1a. - Ultimate mechanical properties.

Material	Dry		Damp		Underwater	
	Tensile (lb/in^2)	Elong (%)	Tensile (lb/in^2)	Elong (%)	Tensile (lb/in^2)	Elong (%)
Aquatapoxy	270	4	250	4	150	3
Aquatapoxy Flex	240	13	240	9	150	5
Bostik 915	50	130	50	130	40	110
Bostik 1000	50	300	50	300	40	110
Dow 795	90	250	50	60	10	10
Dow 888	50	900	30	570	15	80
Dynatrol 1	100	120	100	80	40	20
Koch 9015	20	770	20	450	10	130
Koch 9028	25	350	20	150	5	20
PRC 7000	30	240	20	70	10	80
Sikaflex 1A	120	580	110	500	50	70
Sikaflex 2C	80	320	60	110	40	60
Sonneborne NP-2	80	130	60	80	5	30
U-Seal 3200	20	300	15	300	10	300
Vulkem 116	50	80	50	80	40	70
Vulkem 202	30	200	30	200	10	80

Table 1b. - Ultimate mechanical properties (percent of dry).

Material	Dry		Damp		Underwater	
	Tensile (lb/in^2)	Elong (%)	Tensile (% of dry)	Elong (% of dry)	Tensile (% of dry)	Elong (% of dry)
Aquatapoxy	270	4	93	100	56	75
Aquatapoxy Flex	240	13	100	69	63	38
Bostik 915	50	130	100	100	80	85
Bostik 1000	50	300	100	100	80	37
Dow 795	90	250	56	24	11	4
Dow 888	50	900	60	63	30	9
Dynatrol 1	100	120	100	67	40	17
Koch 9015	20	770	100	58	50	17
Koch 9028	25	350	80	43	20	6
PRC 7000	30	240	67	29	33	33
Sikaflex 1A	120	580	92	86	42	12
Sikaflex 2C	80	320	75	34	50	19
Sonneborne NP-2	80	130	75	62	3	23
U-Seal 3200	20	300	75	100	50	100
Vulkem 116	50	80	100	100	80	88
Vulkem 202	30	200	100	100	33	40

The other half of the specimens were tested for tensile modulus of elasticity at 25 and 50 percent elongation. These modulus specimens were then placed underwater to simulate service conditions, and retested for modulus every 2 to 4 weeks for a total of 26 weeks

(6 months). The end point (failure) for the modulus test was either a negative slope on the stress-strain curve, or more than 50 percent adhesive failure. None of the sealants failed cohesively in this study. This is not surprising, as one would expect the wet installation conditions to interfere with the bond and lead to premature adhesive, rather than cohesive, failures.

Scoring. - The average number of weeks to failure for the duplicate specimens was converted to a numeric score (0 to 10) as shown in the table below. For example, if one specimen survived 26 weeks without failure (26+), and its duplicate failed at week 22, then their average time to failure would be 24+ weeks (score = 9). To earn a perfect score of 10, both specimens must survive 26 weeks of testing without failure (26+).

Score	Weeks to Failure
10	26+
9	24-26
8	21-23
7	18-20
6	15-17
5	12-14
4	9-11
3	6-8
2	3-5
1	1-2
0	0

The individual data sheets for each sealant are included in the appendix. The results are summarized in table 2 below.

Table 2. - Summary - modulus tests.

Materials	Dry		Damp		Underwater	
	Weeks to failure	Score	Weeks to failure	Score	Weeks to failure	Score
Sikaflex 1A	26+	10	26+	10	26+	10
U-Seal 3200	26+	10	26+	10	26+	10
Boxtik 915	26+	10	26+	10	26	9
Sikaflex 2C	26+	10	26+	10	6	3
Koch 9015	26+	10	26+	10	4	2
Vulkem 116	16	6	22	8	7	3
Koch 9028	26+	10	17+	6-1/2	10	4
Bostik 1000	26+	10	16+	6	18+	7
Vulkem 202	9	4	16+	6	6	3
Dow 888	26+	10	16	6	8	3
PRC 7000	19	7	16	6	5	2
Dynatrol 1	24+	9	14+	5-1/2	6	3
Sonneborne NP-2	26+	10	6	3	4	2
Dow 795	21+	8	4	2	0	0
Aquatapoxy	0	0	0	0	0	0
Aquatapoxy Flex	0	0	0	0	0	0

DISCUSSION

Ultimate Mechanical Properties

The results of the ultimate mechanical properties testing (tables 1a and 1b) show that most of the sealants bonded relatively well to the damp concrete. Several sealants showed virtually no loss in tensile strength or elongation. A couple of sealants (Vulkem 116 and Bostik 915) even demonstrated good retention of ultimate mechanical properties when applied underwater.

However, the modulus tests show that retention of short-term ultimate mechanical properties is only a screening test and is not a good indicator of long-term performance. For instance, Vulkem 116 demonstrated good short-term mechanical properties when applied underwater; however, it did not prove durable in the modulus test as it quickly lost bond (7 weeks to failure).

Modulus Test

Modulus of elasticity readings were taken at 25 and 50 percent elongation. This test is somewhat severe because, in the field, sealants are not expected to experience more than 25 percent movement, and usually less than that. Modulus tests were performed every 2 to 4 weeks and terminated after 6 months. A previous study (Report No. R-93-09) found that specimens surviving the first 6 months would likely survive the entire 4-year duration of that study. This extrapolation may not be entirely accurate for this study because the adverse installation conditions may affect bond durability. However, sealants that performed well in this study for 6 months are anticipated to provide years of satisfactory service in the field. Proper installation will of course be critical. Key factors will include surface preparation and adequate tooling to achieve bond between the sealant and the wet concrete.

RECOMMENDATIONS

Sealants for Application to Either Damp-wet Concrete or Underwater Concrete

The following sealants received high (8 to 10) or moderate (5 to 7) scores both in damp-wet installation conditions, and when applied underwater. These sealants bonded to the concrete and withstood occasional joint opening of 50 percent for up to 26+ weeks.

Sikaflex 1A. - This one-part sealant received perfect scores both in damp and underwater applications (Score: Underwater = 10, Damp = 10).

Burke U-Seal 3200. - This two-part self-leveling sealant received perfect scores both in damp and underwater applications. However it is extremely soft (1 lb/in^2 modulus), and may be susceptible to mechanical damage and possibly cold flow under hydrostatic pressure. The sealant manufacturer says they can modify the formulation for these applications by removing the water scavenger chemicals to prevent soft, spongy sealant without sacrificing other physical properties. Burke U-Seal 3202 is the non-sag version of this material (Score: Underwater = 10, Damp = 10).

Bostik 915. - This one-part sealant performed quite well both in damp and underwater applications. It is a less expensive version of Bostik 1000 and has lower ultimate mechanical properties. However it proved to be less sensitive to wet application conditions and outperformed its higher priced sibling (Score: Underwater = 9, Damp = 10).

Bostik 1000. - This one-part sealant earned borderline scores both in damp and underwater applications (Score: Underwater = 7, Damp = 6).

Sealants for Application to Damp-wet Concrete Only

The following sealants did not perform well when applied underwater; however, they did receive high (8 to 10) or moderate (5 to 7) scores when applied to damp concrete.

Sikaflex 2C. - This two-part sealant received a perfect score when applied to damp concrete (Score: Underwater = 3, Damp = 10).

Koch 9015. - This two-part, rapid-set sealant received a perfect score when applied to damp concrete. In the field, special application equipment is needed to accommodate its quick setting time (Score: Underwater = 2, Damp = 10).

Vulkem 116. - This one-part sealant performed well when applied to damp concrete (Score: Underwater = 3, Damp = 8).

Koch 9028. - This two-part sealant received a borderline damp-application score. Reclamation has used this product for application to green concrete with satisfactory results (Score: Underwater = 4, Damp = 6½).

Vulkem 202. - This two-part self-leveling sealant received a borderline damp-application score. It has limited application because it can only be used on horizontal surfaces (Score: Underwater = 3, Damp = 6).

Dow 888. - This one-part silicone sealant received a borderline damp-application score. It should be considered for applications where larger than normal joint movement is anticipated because silicone sealants have higher movement capabilities (±50 percent) than most other sealants (±25 percent) (Score: Underwater = 3, Damp = 6).

PRC 7000. - This one-part sealant received a borderline damp-application score. However, it seemed the easiest to tool into intimate contact with the wet concrete (Score: Underwater = 2, Damp = 6).

Dynatrol I. - This one-part sealant received only a borderline damp-application score. Also it had an objectionable odor (Score: Underwater = 3, Damp = 5½).

Specialty Products

Aquatapoxy. - This epoxy scored poorly in this study because it can accommodate only 3 to 5 percent elongation (Score: Underwater = 0, Damp = 0).

Aquatapoxy Flex. - This flexible epoxy also scored poorly in this study; however, it can accommodate 5 to 15 percent elongation and may have sufficient flexibility to function as a canal sealant. It is specifically formulated for underwater installation and may be less sensitive to surface preparation than other joint materials (Score: Underwater = 0, Damp = 0).

APPENDIX

Test Results – Data Tables

BOSTIK 915

Modulus (psi) at 25% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	COMMENTS
7-16-92	0	31	28	30	28	26	25	
7-28-92	2	29	27	27	26	23	23	
8-11-92	4	29	28	29	28	26	25	
8-26-92	6	27	25	26	25	23	22	U-3 10% Adh, U-4 10% Adh
9- 9-92	8	27	26	27	26	26	23	
9-24-92	10	29	27	27	26	26	25	
11- 6-92	16	29	27	27	27	27	25	
12-15-92	22	22	26	26	25	25	24	
1-12-93	26	26	27	26	26	27	25	

Modulus (psi) at 50% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	FAILURES
7-16-92	0	43	39	42	40	35	34	
7-28-92	2	43	40	40	40	34	33	
8-11-92	4	44	42	43	42	37	36	
8-26-92	6	42	39	40	38	34	33	
9- 9-92	8	41	40	41	40	37	34	
9-24-92	10	43	40	40	39	37	35	
11- 6-92	16	42	40	41	41	37	36	
12-15-92	22	36	39	40	38	37	35	
1-12-93	26	39	38	39	39	38	Fail	U-4 100% Adhesive Failure

BOSTIK 1000

Modulus (psi) at 25% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	COMMENTS
7-16-92	0	23	22	23	26	21	19	
7-28-92	2	20	19	20	21	18	17	U-4 15% Adhesive Failure
8-11-92	4	20	20	21	22	19	17	U-4 20% Adhesive Failure
8-26-92	6	19	19	19	Fail	18	14	U-4 35% Adhesive Failure
9- 9-92	8	19	19	21		19	14	U-4 45% Adhesive Failure
9-24-92	10	20	20	21		20	Fail	
11- 6-92	16	21	20	21		20		
12-15-92	22	19	18	20		19		
1-12-93	26	20	19	21		20		

Modulus (psi) at 50% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	FAILURES
7-16-92	0	32	31	32	35	30	27	
7-28-92	2	29	29	30	31	27	25	
8-11-92	4	30	31	31	32	29	25	
8-26-92	6	30	30	30	Fail	28	21	D-4 80% Adhesive Failure
9- 9-92	8	29	30	32		29	21	
9-24-92	10	31	32	33		30	Fail	U-4 90% Adhesive Failure
11- 6-92	16	32	32	33		30		
12-15-92	22	31	30	31		30		
1-12-93	26	32	30	32		30		

DOW 795

Modulus (psi) at 25% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	COMMENTS
7-16-92	0	35	35	33	31	Fail	Fail	
7-28-92	2	26	26	26	Fail			
8-11-92	4	26	26	25				D-3 40% Adhesive Failure
8-26-92	6	23	23	Fail				
9- 9-92	8	24	24					
9-24-92	10	24	24					
11- 6-92	16	Fail	25					
12-15-92	22		23					
1-12-93	26		23					

Modulus (psi) at 50% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	FAILURES
7-16-92	0	50	50	48	36	Fail	Fail	U-3 & U-4 100% Adh Fail
7-28-92	2	45	45	45	Fail			D-4 75% Adhesive Failure
8-11-92	4	46	46	32				
8-26-92	6	44	44	Fail				D-3 100% Adhesive Failure
9- 9-92	8	44	45					
9-24-92	10	42	44					
11- 6-92	16	Fail	46					A-3 95% Adhesive Failure
12-15-92	22		42					
1-12-93	26		42					

DOW 888

Modulus (psi) at 25% elongation

		AIR (dry)		DAMP		UNDER WATER		
date	week	#3	#4	#3	#4	#3	#4	COMMENTS
7-16-92	0	17	16	18	16	14	Fail	U-3 15% Adhesive Failure
7-28-92	2	14	14	15	14	12		U-3 15% Adhesive Failure
8-11-92	4	13	13	14	13	11		D-3 10% Adh, U-3 15% Adh
8-26-92	6	11	11	13	10	8		D-3 20% Adh, U-3 20% Adh
9- 9-92	8	13	13	14	13	9		D-3 25% Adh, U-3 30% Adh
9-24-92	10	13	13	Fail	12	8		U-3 40% Adhesive Failure
11- 6-92	16	13	13		11	Fail		
12-15-92	22	13	12		Fail			
1-12-93	26	15	14					

Modulus (psi) at 50% elongation

		AIR (dry)		DAMP		UNDER WATER		
date	week	#3	#4	#3	#4	#3	#4	FAILURES
7-16-92	0	19	19	20	18	14	Fail	U-4 90% Adhesive Failure
7-28-92	2	18	17	18	17	14		
8-11-92	4	17	17	18	17	14		
8-26-92	6	15	15	17	15	11		
9- 9-92	8	17	17	19	17	12		
9-24-92	10	18	17	Fail	16	10		D-3 75% Adhesive Failure
11- 6-92	16	18	17		17	Fail		U-3 60% Adhesive Failure
12-15-92	22	17	17		Fail			D-4 100% Adhesive Failure
1-12-93	26	20	18					

DYNATROL 1

Modulus (psi) at 25% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	COMMENTS
7-16-92	0	63	59	63	63	42	45	U-3 30% Adh, U-4 20% Adh
7-28-92	2	40	39	42	Fail	27	31	U-3 30% Adh, U-4 20% Adh
8-11-92	4	40	38	40		Fail	29	U-4 20% Adhesive Failure
8-26-92	6	39	37	38			24	D-3 10% Adh, U-4 50% Adh
9- 9-92	8	41	38	40			Fail	
9-24-92	10	40	38	39				A-4 15% Adhesive Failure
11- 6-92	16	40	33	39				D-3 10% Adhesive Failure
12-15-92	22	35	Fail	34				D-3 20% Adhesive Failure
1-12-93	26	35		32				

Modulus (psi) at 50% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	FAILURES
7-16-92	0	93	87	92	90	49	57	
7-28-92	2	55	55	59	Fail	38	46	D-4 100% Adhesive Failure
8-11-92	4	57	53	58		Fail	43	U-3 Neg Slope (50% Adh)
8-26-92	6	56	53	56			35	
9- 9-92	8	60	55	59			Fail	U-4 70% Adhesive Failure
9-24-92	10	58	54	58				
11- 6-92	16	58	48	56				
12-15-92	22	52	Fail	52				A-4 75% Adhesive Failure
1-12-93	26	52		49				

KOCH 9015

Modulus (psi) at 25% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	COMMENTS
7-16-92	0	7	8	10	10	Fail	8	
7-28-92	2	7	7	10	10		8	
8-11-92	4	8	8	11	11		9	U-4 10% Adhesive Failure
8-26-92	6	6	7	10	10		7	U-4 20% Adhesive Failure
9- 9-92	8	8	7	11	10		Fail	
9-24-92	10	8	7	11	12			
11- 6-92	16	9	9	12	12			
12-15-92	22	9	9	11	11			
1-12-93	26	8	8	12	12			

Modulus (psi) at 50% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	FAILURES
7-16-92	0	8	9	12	13	Fail	9	U-3 85% Adhesive Failure
7-28-92	2	8	9	12	13		10	
8-11-92	4	9	10	14	14		11	
8-26-92	6	8	8	13	12		8	
9- 9-92	8	9	9	14	13		Fail	U-4 70% Adhesive Failure
9-24-92	10	10	11	15	15			
11- 6-92	16	10	11	16	15			
12-15-92	22	11	11	15	14			
1-12-93	26	10	10	16	15			

KOCH 9028

Modulus (psi) at 25% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #5	COMMENTS
7-16-92	0	9	8	11	13	7	8	D-4 20% Adh, U-5 50% Adh
7-28-92	2	8	8	9	9	7	5	D-4 25% Adh, U-5 50% Adh
8-11-92	4	9	8	9	8	7	Fail	D-4 30% Adh, U-3 10% Adh
8-26-92	6	8	6	8	5	6		D-4 50% Adh, U-3 10% Adh
9- 9-92	8	9	8	9	Fail	6		U-3 20% Adhesive Failure
9-24-92	10	9	8	9		7		U-3 40% Adhesive Failure
11- 6-92	16	9	8	9		Fail		
12-15-92	22	9	7	9				
1-12-93	26	9	8	9				

Modulus (psi) at 50% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #5	FAILURES
7-16-92	0	13	12	16	16	11	11	
7-28-92	2	13	12	14	12	11	7	
8-11-92	4	14	13	15	12	11	Fail	U-5 70% Adhesive Failure
8-26-92	6	13	11	13	9	9		
9- 9-92	8	13	12	14	Fail	9		D-4 80% Adhesive Failure
9-24-92	10	14	12	14		11		
11- 6-92	16	14	13	15		Fail		U-3 70% Adhesive Failure
12-15-92	22	14	12	15				
1-12-93	26	14	13	14				

PRC 7000

Modulus (psi) at 25% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	COMMENTS
7-16-92	0	7	6	8	8	6	4	U-4 20% Adhesive Failure
7-28-92	2	8	8	9	9	10	8	U-4 25% Adhesive Failure
8-11-92	4	8	8	9	8	Fail	9	D-4 20% Adh, U-4 30% Adh
8-26-92	6	7	7	8	Fail		Fail	D-3 10% Adhesive Failure
9- 9-92	8	9	9	9				
9-24-92	10	9	9	9				
11- 6-92	16	8	Fail	9				D-3 15% Adhesive Failure
12-15-92	22	Fail		7				D-3 30% Adhesive Failure
1-12-93	26			Fail				

Modulus (psi) at 50% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	FAILURES
7-16-92	0	11	10	13	13	9	6	
7-28-92	2	12	13	13	13	12	11	
8-11-92	4	13	13	13	12	Fail	12	U-3 90% Adhesive Failure
8-26-92	6	11	12	12	Fail		Fail	D-4 95% Adh, U-4 85% Adh
9- 9-92	8	13	13	13				
9-24-92	10	13	13	13				
11- 6-92	16	13	Fail	13				A-4 70% Adhesive Failure
12-15-92	22	Fail		11				A-3 100% Adhesive Failure
1-12-93	26			Fail				D-3 65% Adhesive Failure

SIKAFLEX 1A

Modulus (psi) at 25% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	COMMENTS
7-16-92	0	48	48	50	48	47	46	
7-28-92	2	46	44	43	40	35	35	
8-11-92	4	47	45	46	43	38	38	
8-26-92	6	46	43	46	42	37	40	D-3 10%, U-3 10%, U-4 15%
9- 9-92	8	45	44	43	42	36	37	
9-24-92	10	46	45	43	43	37	38	
11- 6-92	16	45	45	43	42	37	38	D-3 15%, U-3 15%, U-4 15%
12-15-92	22	42	41	39	39	34	34	D-3 20%, U-3 15%, U-4 15%
1-12-93	26	43	42	39	39	36	36	

Modulus (psi) at 50% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	FAILURES
7-16-92	0	63	62	65	63	61	61	No Failures!
7-28-92	2	64	62	61	58	50	51	
8-11-92	4	67	65	65	62	54	54	
8-26-92	6	66	62	65	61	55	56	
9- 9-92	8	64	63	61	60	52	53	
9-24-92	10	64	64	61	62	53	55	
11- 6-92	16	63	62	60	60	53	54	
12-15-92	22	61	60	57	58	51	51	
1-12-93	26	61	60	56	56	50	52	

SIKAFLEX 2C

Modulus (psi) at 25% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	COMMENTS
7-16-92	0	27	28	26	26	27	28	U-3 40% adhesive Failure
7-28-92	2	20	19	21	22	Fail	22	
8-11-92	4	23	23	21	19		22	D-4 10% Adhesive Failure
8-26-92	6	25	25	23	21		22	D-4 15% Adh, U-4 10% Adh
9- 9-92	8	22	23	21	18		19	D-4 20% Adh, U-4 15% Adh
9-24-92	10	23	24	20	18		Fail	D-4 30% Adhesive Failure
11- 6-92	16	23	23	20	18			
12-15-92	22	20	20	16	16			D-3 10% Adh, D-4 45% Adh
1-12-93	26	22	22	18	13			

Modulus (psi) at 50% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	FAILURES
7-16-92	0	41	43	39	39	33	39	
7-28-92	2	31	29	31	33	Fail	34	U-3 Neg Slope (40% Adh)
8-11-92	4	34	35	32	30		34	
8-26-92	6	39	39	35	32		34	
9- 9-92	8	35	37	34	30		32	
9-24-92	10	36	38	33	30		Fail	U-4 60% Adhesive Failure
11- 6-92	16	37	37	33	29			
12-15-92	22	34	35	29	27			
1-12-93	26	35	36	30	24			

SONOLASTIC NP-2

Modulus (psi) at 25% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	COMMENTS
7-16-92	0	38	34	25	34	11	1	U-3 30% Adh, U-4 50% Adh
7-28-92	2	34	28	20	29	5	Fail	D-4 30% Adh, U-3 40% Adh
8-11-92	4	30	26	18	Fail	5		U-3 50% Adhesive Failure
8-26-92	6	27	22	15		Fail		D-3 10% Adhesive Failure
9- 9-92	8	26	22	Fail				
9-24-92	10	25	21					
11- 6-92	16	23	20					
12-15-92	22	22	19					
1-12-93	26	22	18					

Modulus (psi) at 50% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	FAILURES
7-16-92	0	55	49	36	49	12	2	
7-28-92	2	50	42	31	41	8	Fail	U-4 75% Adhesive Failure
8-11-92	4	45	39	27	Fail	8		D-4 Neg Slope (50% Adh)
8-26-92	6	41	34	23		Fail		U-3 60% Adhesive Failure
9- 9-92	8	39	33	Fail				D-3 70% Adhesive Failure
9-24-92	10	37	32					
11- 6-92	16	35	30					
12-15-92	22	34	29					
1-12-93	26	33	28					

VULKEM 116

Modulus (psi) at 25% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	COMMENTS
7-16-92	0	24	26	21	24	20	18	
7-28-92	2	16	18	14	18	16	15	
8-11-92	4	17	18	15	19	Fail	14	U-4 10% Adhesive Failure
8-26-92	6	19	20	16	19		16	A-3 10%, D-3 20%, U-4 20%
9- 9-92	8	18	18	14	19		14	A-3 10%, D-3 20%, U-4 20%
9-24-92	10	16	Fail	15	19		Fail	A-3 40%, D-3 40%, D-4 45%
11- 6-92	16	13		14	14			A-3 40%, D-3 40%, D-4 45%
12-15-92	22	Fail		Fail	Fail			
1-12-93	26							

Modulus (psi) at 50% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	FAILURES
7-16-92	0	40	42	35	41	34	30	
7-28-92	2	31	33	27	34	30	28	
8-11-92	4	32	34	29	36	Fail	27	U-3 Neg Slope (35% Adh)
8-26-92	6	35	37	31	38		29	
9- 9-92	8	33	34	30	37		25	
9-24-92	10	30	Fail	28	32		Fail	A-4 60% Adh, U-4 60% Adh
11- 6-92	16	24		26	26			
12-15-92	22	Fail		Fail	Fail			A-3 70%, D-3 60%, D-4 75%
1-12-93	26							

VULKEM 202

Modulus (psi) at 25% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	COMMENTS
7-16-92	0	8	10	6	6	2	2	
7-28-92	2	9	11	6	6	3	2	
8-11-92	4	9	11	7	7	3	3	U-4 15% Adhesive Failure
8-26-92	6	9	11	Fail	7	Fail	Fail	
9- 9-92	8	10	Fail		7			A-3 30% Adhesive Failure
9-24-92	10	Fail			7			
11- 6-92	16				7			
12-15-92	22				6			
1-12-93	26				7			

Modulus (psi) at 50% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	FAILURES
7-16-92	0	14	16	9	9	4	3	
7-28-92	2	15	17	10	10	5	4	
8-11-92	4	15	17	11	10	5	5	
8-26-92	6	15	17	Fail	10	Fail	Fail	D-3 95%, U-3 75%, U-4 75%
9- 9-92	8	15	Fail		10			A-4 100% Adhesive Failure
9-24-92	10	Fail			11			A-3 100% Adhesive Failure
11- 6-92	16				11			
12-15-92	22				10			
1-12-93	26				11			

BURKE U-SEAL 3200

Modulus (psi) at 25% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	COMMENTS
7-16-92	0	5	5	2	1	1	1	D-3, D-4, U-3, & U-4
7-28-92	2	4	4	2	1	1	1	all absorbed water -
8-11-92	4	5	5	2	1	1	1	Very Spongy!
8-26-92	6	5	5	2	1	1	1	
9- 9-92	8	5	5	2	1	1	1	
9-24-92	10	5	4	3	2	1	1	
11- 6-92	16	4	4	2	1	1	1	
12-15-92	22	4	4	2	1	1	1	
1-12-93	26	4	4	1	1	1	1	

Modulus (psi) at 50% elongation

date	week	AIR (dry) #3	AIR (dry) #4	DAMP #3	DAMP #4	UNDER WATER #3	UNDER WATER #4	FAILURES
7-16-92	0	8	8	3	2	1	1	No Failures!
7-28-92	2	7	7	2	1	1	1	
8-11-92	4	7	7	2	1	1	1	
8-26-92	6	7	7	2	1	1	1	
9- 9-92	8	7	7	2	1	1	1	
9-24-92	10	7	7	3	2	2	1	
11- 6-92	16	7	7	3	1	1	1	
12-15-92	22	7	6	2	1	1	1	
1-12-93	26	7	7	2	2	1	1	

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Mission

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American Public.