

RECLAMATION

Managing Water in the West

Development of Practical Guidelines to Achieve Compatibility in Concrete Repairs and Overlays - Scoping Study

**Research and Development Office
Science and Technology Program
(Final Report) ST-2017-7103-01 (8530-2017-36)**



**U.S. Department of the Interior
Bureau of Reclamation
Research and Development Office**

September 2017

Mission Statements

Protecting America's Great Outdoors and Powering Our Future

The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

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REPORT DOCUMENTATION PAGE			<i>Form Approved</i> OMB No. 0704-0188		
T1. REPORT DATE: SEPTEMBER 2017		T2. REPORT TYPE: RESEARCH		T3. DATES COVERED	
T4. TITLE AND SUBTITLE Development of Practical Guidelines to Achieve Compatibility in Concrete Repairs and Overlays - Scoping Study			5a. CONTRACT NUMBER 17XR0680A1-RY15412017IS17103 (8)		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER 1541 (S&T)		
6. AUTHOR(S) Shannon Harrell, P.E. sharrell@usbr.gov 303-445-2370			5d. PROJECT NUMBER ST-2017-7103-01		
			5e. TASK NUMBER		
			5f. WORK UNIT NUMBER 86-68530		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Shannon Harrell, P.E. Bureau of Reclamation Technical Services Center Concrete, Geotechnical, and Structural Laboratory (86-68530)			8. PERFORMING ORGANIZATION REPORT NUMBER 8530-2017-36		
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Research and Development Office U.S. Department of the Interior, Bureau of Reclamation, PO Box 25007, Denver CO 80225-0007			10. SPONSOR/MONITOR'S ACRONYM(S) R&D: Research and Development Office BOR/USBR: Bureau of Reclamation DOI: Department of the Interior		
			11. SPONSOR/MONITOR'S REPORT NUMBER(S) ST-2017-7103-01		
12. DISTRIBUTION / AVAILABILITY STATEMENT Final report can be downloaded from Reclamation's website: https://www.usbr.gov/research/					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT (Maximum 200 words) The primary objective of this study was to meet with leading experts in the field of concrete repair and form a focus group to study the issues of concrete repair material compatibility. A literature review was performed which discusses some of the related research that potential partners have been conducting in the field of repair material compatibility. Conclusions were drawn from the meetings conducted.					
15. SUBJECT TERMS concrete repair; test methods; repair material					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT U	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON Shannon Harrell, P.E.
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U			19b. TELEPHONE NUMBER 303-445-2370

BUREAU OF RECLAMATION

**Research and Development Office
Science and Technology Program**

Concrete, Geotechnical, and Structural Laboratory, 86-68530

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Development of Practical Guidelines to Achieve Compatibility in Concrete Repairs and Overlays - Scoping Study

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Acronyms and Abbreviations

ACI	American Concrete Institute
ASR	Alkali-Silica Reaction
ASTM	American Society for Testing and Materials
F/T	Freeze-Thaw
ICRI	International Concrete Repair Institute
NIST	National Institute of Standards and Technology
SDC	Strategic Development Council
SSD	Saturated Surface Dry

Executive Summary

The primary objective of this study was to meet with leading experts in the field of concrete repair and form a focus group to study the issues of concrete repair material compatibility. A literature review was performed which discusses some of the related research that potential partners have been conducting in the field of repair material compatibility.

One aspect of concrete repair that has plagued concrete repair experts and has not been extensively studied is concrete repair material compatibility with the existing substrate and service environment. It is a very complex issue.

Practical guidelines for an engineer to follow when determining if the repair material will be durable and withstand the loads and stresses that have been imposed on the repaired or overlaid concrete have not been developed. This focus group was developed to discuss what compatibility issues need to be studied to bring the industry closer to having practical guidelines.

Some of the next steps that came out of this study were the following:

- Reclamation should consider requiring ICRI's Concrete Surface Repair Technician (CSRT) Certification on all concrete repair projects.
- Reclamation should help facilitate developing a common repository for file sharing and distribution of ongoing and past research in the field of concrete repair compatibility.
- Future studies should focus on the development of a practical test to determine the shear strength at a bonded overlay interface.
- Reclamation should consider sending a representative to work with ACI 364 Rehabilitation Committee as their work is directly related to the scope of this project.

Contents

Executive Summary	vi
Abstract	8
Background	8
Conclusions	9
Discussion	9
Meetings	9
Literature Review	12
Previous Reclamation Studies	12
Shear Strength at the Interface of Bonded Overlays	13
Tensile Bond Strength at Grout-Concrete Interface	14
Results	14
Recommendations for Next Steps	15
References	16
Appendix A – Meeting Minutes	A-1
Appendix B – Repair Compatibility Storyboard	B-1

Tables

Table 1. Meeting Schedule, Attendees, and Purpose	10
Table 2. List of Potential Partners Whom Expressed Interest	11
Table 3. List of Potential Partners Whom Declined or Provided No Response	12

Abstract

The primary objective of this study was to meet with leading experts in the field of concrete repair and form a focus group to study the issues of concrete repair material compatibility. A literature review was performed which discusses some of the related research that potential partners have been conducting in the field of repair material compatibility. Conclusions were drawn from the meetings conducted.

Background

One aspect of concrete repair that has plagued concrete repair experts and has not been extensively studied is concrete repair material compatibility with the existing substrate and service environment. It is a very complex issue. The old rule-of-thumb for compatibility was to replace like with like. But how do you replace old damaged concrete that has been exposed for years in a specific environment with something similar? The old rule is simply not useful.

Practical guidelines for an engineer to follow when determining if the repair material will be durable and withstand the loads and stresses that have been imposed on the repaired or overlaid concrete have not been developed. Reclamation Report No. MERL-2014-87 - Compatibility Issues in Design and Implementation of Concrete Repairs and Overlays [1], outlined five compatibility factors that determine if the concrete overlay or repair will be a good fit: dimensional, permeability, electrochemical, chemical, and aesthetic.

This scoping study will focus on dimensional, permeability, and chemical compatibility as the compatibility factors that would be of most importance to Reclamation structures. The intent of this study is to work with industry leading experts in determining how we can develop guidelines and what they would look like. This study will consist of meeting with experts to develop a future research strategy which will focus on the five compatibility issues identified in the Reclamation MERL-2014-87 report. As a partner in the group, Reclamation will focus on dimensional, permeability, and chemical compatibility. The group will be open to other compatibility issues that have not been previously identified.

Before a conducting study can take place, researchers need to determine if all the factors related to compatibility have been identified and if any further investigations of those factors need to be conducted. The field of concrete repair material compatibility can be very broad, so this study will coordinate focus groups that will identify the key issues and research efforts that would lead to usable guidelines in the future.

Conclusions

- During the final meeting, some of the potential partners expressed interest in the following research areas:
 - Several potential partners expressed interest in developing a standard ASTM test for determining shear strength at bonded overlay interfaces (UC Denver, VDOT).
 - WJE is interested in correlating shear strength with pull-off test.
- The final meeting also included discussions about the importance of specifying ICRI's Concrete Surface Repair Technician (CSRT) Certification on all repair projects.
- The group is interested in establishing a common repository for file sharing and distribution.
- Reclamation research topics for future study include the following:
 - Alkali-Silica Reaction (ASR) - Would alkalis in concrete repair materials accelerate the reaction at the interface and lead to problems such as bond failure? (chemical compatibility)
 - Shrinkage Testing - Packaged repair mortar manufacturers produce and market "low-shrinkage" mortars in an attempt to mitigate cracking and premature failure of the repair material. Unfortunately, the meaning of "low-shrinkage" is vague, is measured in different ways, and the actual field performance is mixed at best. (dimensional compatibility)
 - Impervious repair mortar with a pervious substrate - Would an impervious repair mortar over a pervious substrate accelerate freeze-thaw (F/T) deterioration by trapping moisture in the substrate? (permeability compatibility)
- ACI Committee 364 is in the process of updating the Data Sheet Protocol. Involvement in this committee would be beneficial for Reclamation. The research performed by Reclamation as a follow-up to this scoping study may be useful to the committee as they work to update the protocol.

Discussion

Meetings

This scoping study focused on meeting with other leading experts in the concrete repair industry to further develop the field of concrete repair material compatibility. There are many in the private sector, government, and academia that have been studying concrete repair compatibility. Reclamation's hope is to bring together a group that will focus on these issues and potentially have workshops down the road. Table 1 below is a list of the meetings we held, the people in attendance, and the purpose of the group.

Development of Practical Guidelines to Achieve Compatibility in Concrete Repairs and Overlays - Scoping Study

Benoit Bissonnette is a leading expert in concrete repair. Reclamation has collaborated with him several times in years past. Concrete repair compatibility is high on his priority list, and therefore, he was one of the first potential partners we reached out to. Bissonnette has numerous contacts throughout the concrete repair industry, so we called upon him to help prepare a list of potential partners. A storyboard was developed during the first few meetings which was sent out to gauge interest from other potential partners on our list. The storyboard can be found in Appendix B. Table 2 is a list of partners that expressed interest in either being a part of the group, or following the work of the group. Table 3 is a list of potential partners that we reached out to, but from whom we did not receive any reply or they declined to be a part of the group.

The first large group meeting occurred at the Strategic Development Council (SDC) Spring Convention in February. SDC is a council of the American Concrete Institute (ACI) Foundation and was formed to “facilitate advancement in concrete technology” [2]. SDC also “discuss[es] strategic issues and tactics including support of practical research,” which made it an ideal place to present our mission to other concrete experts [2]. There was a second large group meeting in May that took place via conference call to include some of the interested potential partners that were unable to attend the Spring SDC Convention.

Table 1. Meeting Schedule, Attendees, and Purpose

No.	Date	Attendees	Primary Purpose
1	December 5, 2016	Reclamation Only	In-house Kickoff Meeting.
2	December 14, 2016	Reclamation Benoit Bissonnette	Develop List of Potential Partners. Discuss Development of Storyboard.
3	December 21, 2016	Reclamation Benoit Bissonnette	Discussed Storyboard. Discussed joint meeting location w/ Partners. Discussed potential future workshops.
4	February 22, 2017	Reclamation Potential Partners at SDC meeting	Discussed w/ the group Reclamation's mission for this Partnership.
5	March 22, 2017	Reclamation Benoit Bissonnette	Discussed new interested partners. Recapped SDC meeting. Discussed BOR research ideas.
6	May 16, 2017	Reclamation Potential Partners	Discussed BOR research ideas and interests. Potential partners discussed their research interests.

Table 2. List of Potential Partners Whom Expressed Interest

Company	Individual	Job Title
Laval University	Bissonnette, Benoit*	Full Professor
BASF	Goodwin, Fred	Head of BASF Construction Chemicals Global Corrosion Competency Center
ChemCognition	Manissero, Claudio	President and Cofounder
Conproco Corp.	Brown, Christopher	President
CVM Engineers	Kesner, Keith	Project Manager, Structural Engineer
	Marcotte, Tracy	Principal
Euclid Chemical	Talbot, Caroline	Director, Key Accounts and Tunelling Division
National Institute of Standards and Technology (NIST)	Bentz, Dale	Chemical Engineer
	Ferraris, Clarissa	Physicist
Premier Magnesia, LCC (Prevent C)	Preskenis, Jim	Vice President Sales
	Rademan, Jerry	Business and Technology Development Consultant
Sika Corp.	Gillespie, Timothy	Vice President Product Management
Structural Group	Emmons, Peter	Founder and CEO
Turner-Fairbank Highway Research Center- U.S. Federal Highway Administration	De la Varga, Igor	Concrete Materials Research Engineer
USACE-ERDC	Moser, Robert	Research Civil Engineer
	Green, Brian	Research Geologist
University of Colorado Denver	Rutz, Frederick	Associate Professor
	Nogueira, Carnot	Research Assistant Professor
Virginia Center for Transportation Innovation and Research (VCTIR)	Sprinkel, Michael	Associate Director for Structures
Wiss, Janney, Elstner and Associates Inc. (WJE)	Michols, Kevin	Principal, Unit Manager, and Director of Janney Technical Center

*Indicates Co-Partner in this effort

Table 3. List of Potential Partners Whom Declined or Provided No Response

Company	Individual
Baker Concrete Const Inc.	Hausfeld, John
City of Montreal	Morin, Richard
Euclid Admixtures Canada, Inc.	Lessard, Michael
Mapei Inc.	Herbert, Pierre
Port Hueneme- Navy	No Contact
SDC Strategic Repair Research Council	Gosain, Narendra
Simpson Gumpertz & Heger Inc.	Jiang, Liying
Walter P. Moore and Associates	Beard, Randal
Wiss, Janney, Elstner and Associates Inc. (WJE)	Gaudette, Paul
	Harrer, Ann

Literature Review

Previous Reclamation Studies

The 2014 study conducted by Reclamation outlined five compatibility issues that designers are faced with when specifying a long lasting concrete repair. The report was extensive and described each compatibility issue and how it might affect the long term durability and performance of the repair. The results of this study were used as a cornerstone when talking with potential partners. Through this study, a long list of future research ideas were developed, including:

- Investigation on the effect of cement chemistry and fineness on early age cracking. (Dimensional)
- Research on low shrinkage cements, additives to cement to reduce shrinkage, and other very low shrinkage cementitious materials. (Dimensional)
- The influence of repair or overlay shrinkage on the interface bond strength. (Dimensional)

The list above does not list all the recommended studies, but only those that coincided with or are related to the interests of this group.

Reclamation also performed a four-year study in an effort to provide guidelines for moisture conditioning of substrate concrete prior to application of a concrete repair or overlay. The study consisted of casting 5,000 psi slabs, moisture conditioning them to different levels, placing 5,000 psi or 7,000 psi concrete over the substrate, and then performing pull-off testing to determine the effects of the moisture conditioning. The three moisture conditions were zero (0) hours of ponding water, one (1) hour of ponding water followed by allowing the slab to dry at the surface, and six (6) hours of ponding water followed by allowing the slab to dry at the surface. Pull-off tests were conducted at two (2) months and one (1) year later. Earlier years of this study tested 3,000 psi, 5,000 psi, and 7,000 psi substrate concrete as well as a packaged repair materials.

The study concluded that when normal and higher strength (about 5,000 psi and higher) concrete elements are repaired with a portland cement-based material, pre-wetting is not necessary. However, when lower strength concrete elements are repaired or overlaid, a longer 6 hour ponding is recommended. In addition, low-shrinkage (shrinkage-compensating additive concrete) result in higher bond strengths than ordinary concrete repair materials under similar moisture conditions [3].

The authors of this project recommended further study because the results of this study only evaluated a very specific combination of substrates, moisture conditions and repair materials. The authors also recommended codes and guidelines define what SSD condition means for existing concrete and how that might be achieved.

Shear Strength at the Interface of Bonded Overlays

University of Colorado Denver has been studying shear strength at the interface of bonded overlays. One of their students, Christian Johan Rosen, studied shear strength with respect to different test methods and surface treatments. The experiment consisted of testing six different surface preparations. Three pads were prepared by vibrating the concrete during placement and three were not. The three vibrated pads had a surface preparation of broom finished, raked finish, and bush hammer finish. The non-vibrated pads received the same three finish techniques. Rosen tested the concrete overlay bond strength with the substrate using four different test methods; pull-off, slant shear, guillotine, and jacking.

The testing showed surface treatment impacted shear strength at the bonded interface. Compaction of the concrete using the vibrator increased shear strength. Testing also revealed that shear strength varied based on test method [4].

A follow-up study to Rosen's study was conducted at the University of Colorado Denver by Andrew Stephen Pultorak. The project studied the effects of moisture condition of the surface of the substrate and bonding agents on the surface of the substrate prior to placing the bonded overlay. The same four bond tests were conducted on the slabs; pull-off, slant shear, guillotine, and jacking.

Pultorak found that pretreatment, defined as prewetting the surface and/or applying a bonding agent, can improve bond strength. However, an improperly applied bonding agent can have a negative impact on the bond strength. Prewetted substrates resulted in higher bond strengths than dry substrates [5].

A third study on shear strength of bonded interfaces was conducted at the University of Colorado Denver by Anne Elise Swan. This study used two methods for testing shear strength; direct shear using a modified Iosipescu loading scheme and three point flexural shear stress test. Concrete beams were created by casting one concrete layer and then another layer on top. The surface between the two layers received three different surface treatments for the direct shear testing; smooth, bush hammered, and jackhammered. Similarly, the surface between the two layers of concrete in the concrete beams used for flexural shear testing were treated differently; raked, bush hammered, and smooth.

Swan's results showed that the jackhammered surface preparation resulted in a higher direct shear stress than bush hammered and smooth surfaces. The modified Iosipescu method of testing had good repeatability and the author recommended the test for further study and potential standardization. The flexural shear testing had some issues achieving the type of failure modes expected for the testing and was therefore considered unsuccessful for future use [6].

Tensile Bond Strength at Grout-Concrete Interface

The National Institute of Standards and Technology (NIST) and the Federal Highway Administration at Turner-Fairbank Highway Research Center performed a collaborative study on the effects of pre-moistening a concrete substrate prior to the application of a grout overlay. A pull-off test was conducted to see if pre-moistening the concrete substrate would lead to increased bond strength.

The results showed that pull-off test results increased when the concrete substrate was pre-moistened. A microscopic analysis of the interface also showed less porosity and increased hydration of the grout side of the interface. The authors speculated this led to the increased bond strength of the grout to the concrete substrate [7].

Results

There are several outcomes resulting from our discussions with other experts in the concrete repair industry. One of the biggest outcomes was the consensus that there needs to be a practical way to determine shear strength at the bond interface between overlays and the existing substrate. A practical field test needs to be developed or a correlation determined between the shear strength of the bonded interface and the pull-off test. University of Colorado (UC) Denver is interested in this work and would like to be a partner in this effort. Virginia Center for Transportation Innovation and Research and WJE are also interested in this effort.

Reclamation has numerous structures that have been undergoing ASR damage and are in need of repair. One of Reclamation's concerns is that new concrete repair materials may provide additional alkalis to existing ASR deterioration and prolong the effects and lead to bond failures between the new and existing concrete. ChemCognition agreed that ASR deterioration was of interest to their company and they knew of other clients that might be interested in future Reclamation studies. ChemCognition agreed to be a bridge between their clients and Reclamation.

The Mission of ACI Committee 364 Rehabilitation is to "Develop and report information on the analysis, sustainability and design of repair, rehabilitation, and strengthening of existing concrete and masonry structures" [8]. The committee is currently looking to update the "Concrete Repair Material Data Sheet Protocol (ACI 364.3R-09)" and Benoit Bissonnette thought some of the research we are proposing to conduct in the future may contribute to these updates. Bissonnette is the Chair of the Editorial Subcommittee (364-0A).

Recommendations for Next Steps

- Reclamation should consider requiring ICRI's Concrete Surface Repair Technician (CSRT) Certification on all concrete repair projects.
- Reclamation should help facilitate developing a common repository for file sharing and distribution of ongoing and past research in the field of concrete repair compatibility.
- Future studies should focus on the development of a practical test to determine the shear strength at a bonded overlay interface.
- Reclamation should consider sending a representative to work with ACI 364 Rehabilitation committee as their work is directly related to the scope of this project.

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- [1] A. M. Vaysburd, B. Bissonnette and K. F. von Fay, "Compatibility Issues in Design and Implementation of Concrete Repairs and Overlays- MERL-2014-87," U.S. Department of the Interior, Bureau of Reclamation, Denver, CO, 2014.
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- [8] American Concrete Institute, "Committee Home 364- Rehabilitation," American Concrete Institute, [Online]. Available: https://www.concrete.org/committees/directoryofcommittees/acommitteehome.aspx?committee_code=C0036400. [Accessed September 2017].

Appendix A – Meeting Minutes

Repair Compatibility Scoping Study

Meeting 1

December 5, 2016

Attendees: Shannon Harrell, Kurt von Fay, Westin Joy

- 1) The team discussed that the first item on the list was to have a conference call with Benoit Bissonnette (benoitbissonnette@icloud.com) to discuss what their current studies are and any partners that they may know of that we could talk with to discuss the state of our Repair Compatibility studies and re-establish the CREEP team (or something similar).
- 2) We discussed our own thoughts on partners listed in no particular order
 - a. Fred Goodwin – BASF Construction Chemicals
 - b. Peter Emmons – Owner of Structural Group (a private repair company)
 - c. Jim Preskenis – Vice President of Sales - Premier Magnesia, LLC (Prevent C)
 - d. Claudio Manissero – President of ChemCognition
 - e. Navy Contact – Port Hueneme
 - f. Robert Moser – USACE
- 3) We want our studies to focus on compatibility issues. (Specifically, we will focus on dimensional, permeability, and chemical compatibility as the compatibility factors that would be most important to Reclamation.- taken from the proposal)
- 4) We need to set up a phone call with Ben for Wednesday morning, Dec. 14, 2016.
- 5) The purpose of our meeting with Ben is to see what Partners he recommends and inquire about his current research.

Repair Compatibility Scoping Study

Meeting 2 Agenda

December 14, 2016

9:00 a.m. - 10:00 a.m. MST

Attendees: Shannon Harrell, Kurt von Fay, Westin Joy, Benoit Bissonnette

- 1) Who could be some other partners?
 - a. Fred Goodwin – BASF Construction Chemicals
 - b. Peter Emmons – Owner of Structural Group (a private repair company)
 - c. Jim Preskenis – Vice President of Sales - Premier Magnesia, LLC (Prevent C)
 - d. Claudio Manissero – President of ChemCognition
 - e. Navy Contact – Port Hueneme
 - f. Robert Moser – USACE
- 2) We would like to work on practical guidelines.

Notes from the Meeting:

- 1) We envision that each partner brings an individual pot of money that is used to do a part of the research.
- 2) We discussed potential locations and dates for a meeting with partners
 - a. SDC - Feb 22-24 – Dallas, TX
 - i. There is a gap in the schedule on Thursday during which we may be able to have a breakout session.
 - ii. If we go this direction, Kurt can talk to Doug S. about getting a meeting room.
 - iii. This time will likely not work for Ben unless we did something late Friday.
 - b. ACI - March 26-30 – Detroit, Michigan
 - i. Ben is more likely to make it to this location since he will already be there.
 - c. Denver is another potential location if the other dates won't work.
- 3) Shannon to develop draft storyboard for the purpose of this group and research. Ben will receive the draft early next week for review and comments.
- 4) Shannon to send Ben the list of potential partners.
- 5) Shannon will set up another meeting for same time next week.

Repair Compatibility Scoping Study

Meeting 2 Agenda

December 21, 2016

9:00 a.m. - 10:00 a.m. MST

Attendees: Shannon Harrell, Kurt von Fay, Westin Joy, Benoit Bissonnette

- 1) Any comments on the Storyboard that was sent out?
- 2) Have any other partners been identified?
 - a. Fred Goodwin – BASF Construction Chemicals (fred.goodwin@basf.com)
 - b. Peter Emmons – Owner of Structural Group (a private repair company) (pemmons@structural.net)
 - c. Jim Preskenis – Vice President of Sales - Premier Magnesia, LLC (Prevent C) (JPreskenis@premiermagnesia.com, jpreskenis@premiercpg.com)
 - d. Claudio Manissero – President of ChemCognition (claudio@chemcognition.com)
 - e. Navy Contact – Port Hueneme
 - f. Robert Moser – USACE (robert.d.moser@usace.army.mil)
 - g. Narendra Gosain (ngosain@walterpmoore.com), Chair, SDC Strategic Repair Research Council

Notes from the Meeting:

1. Bureau will reword storyboard per meeting discussion and send to Ben for review and comment.
2. Second step is to send the storyboard to potential partners. In the email, the storyboard will be attached and we will ask that interested parties let us know. We will state in the email that we will follow up with a phone call in a few weeks.
3. Ben will go through ACI roster to see if there are any other partners that would be interested. He will see if there are any Navy partners. DOT or FHWA would be other potential partners.
4. Ben cannot meet in Dallas, but it would be worth Shannon talking with people in Dallas. Ben can meet with people in Detroit.
 - a. See if we can talk in conjunction with the research council at SDC.
 - b. We should add Narendra Gosain to the list of potential partners. We should send the email to him and see if he would be interested and support our effort.
 - c. Could our partnership be a part of the 2029 effort? Can this be one of their specific goals?
5. Shannon to try to get the group at SDC 2029 to list compatibility issues as one of the industry critical goals.
6. We should consider doing workshops again. These workshops lead to the first road mapping meeting which led to vision 2020.
 - a. Workshops would focus on compatibility issues.
 - b. Is this something that we want to add to the storyboard? – Add to storyboard, “Depending on interest, we can have workshops that define the research, coordinate the research effort, and defuse the information.”

7. This could lead to commentary in ACI 562.
8. To Do:
 - a. Shannon/Kurt will rewrite the storyboard
 - b. Kurt will write email template that will be sent out to potential partners.

Notes from the Previous Meeting:

- 1) *We envision that each partner brings an individual pot of money that is used to do a part of the research.*
- 2) *We discussed potential locations and dates for a meeting with partners*
 - a. *SDC - Feb 22-24 – Dallas, TX*
 - i. *There is a gap in the schedule on Thursday during which we may be able to have a breakout session.*
 - ii. *If we go this direction, Kurt can talk to Doug S. about getting a meeting room.*
 - iii. *This time will likely not work for Ben unless we did something late Friday.*
 - b. *ACI - March 26-30 – Detroit, Michigan*
 - i. *Ben is more likely to make it to this location since he will already be there.*
 - c. *Denver is another potential location if the other dates won't work.*
- 3) *Shannon to develop draft storyboard for the purpose of this group and research. Ben will receive the draft early next week for review and comments.*
- 4) *Shannon to send Ben the list of potential partners.*
- 5) *Shannon will set up another meeting for same time next week.*

Repair Compatibility Meeting- SDC

February 22, 2017

Attendees: Shannon Harrell, Westin Joy, Tracy Marcotte, Caroline Talbot, Jerry Rademan, Claudio Manissero

- 1) Discuss the 5 compatibility areas/research needs that Reclamation/ Benoit Bissonnette have previously identified as repair compatibility issues.
- 2) Open up the discussion to add other repair issues to the list for consideration.
- 3) Develop research questions for each study area
 - a. What is the expected outcome
- 4) Discuss strategies/methods to address the research needs for the identified areas.
 - a. Group organization
 - b. Coordination meetings
 - c. Funding
- 5) How should the research areas be prioritized? What area(s) of repair is each individual/firm interested in studying?
- 6) Discuss research that is already underway by the parties involved.

Repair Compatibility Scoping Study

Meeting 5 Agenda

March 22, 2017

9:00 a.m. - 10:00 a.m. MST

Attendees: Shannon Harrell, Kurt von Fay, Westin Joy, Benoit Bissonnette

- 1) New Interested Partners
 - a. Dale Bentz – NIST (dale.bentz@nist.gov)
 - b. Igor De la Varga - Turner-Fairbank Highway Research Center- U.S. Federal Highway Administration (igor.delavarga.ctr@dot.gov)
- 2) Any other partners?
- 3) Recap what happened at our meeting at SDC
- 4) Discuss future research ideas that we can present to the team.
- 5) BOR potential ideas-
 - a. ASR- would alkalis in repair mortar kick off reaction @ the interface?
 - b. Shrinkage Testing to tie in with what we are already doing with shrinkage testing
 - c. Impervious repair mortar with a pervious substrate.
 - i. Measure moisture gradient

Meeting Notes:

- 1) We should set up a meeting with potential partners. Here is a list of agenda items recommended by Kurt:
 - a. Potential research subjects related to compatibility
 - i. List the 5 major compatibility issues
 - b. Reclamation is interested in studying these aspects. The hope is to get other parties onboard with these areas of compatibility or commitments in other areas.
 - i. Dimensional- Shrinkage Testing to tie in with what we are already doing with shrinkage testing
 - ii. Permeability- Impervious repair mortar with a pervious substrate.
 1. Measure moisture gradient
 - iii. Chemical- ASR- would alkalis in repair mortar kick off reaction @ the interface?
 - c. Talk about interest in forming a group with regular meetings. Should we have regular formal workshops/meetings? The intent is to have an ongoing group. What kind of group would we have? Perhaps a small group that would meet regularly and then host meetings with a bigger group once every year or every couple of years. Get input from others.
- 2) Consider doing a workshop in FY18. We would put money into next year's proposal to host a workshop.

- a. Consider having a 1-day workshop moved to next fall.
- 3) Westin recommended having a conference call in April/May. We can put together a doodle pole to determine the best day/time for the meeting.
 - a. Agenda and talking points need to be developed prior to meeting
 - b. Discuss that we have support funding to get this started. We want it to be bigger and better which is why we would like others to participate and contribute their own funding to the effort.
 - c. We will put together a doodle pole with meeting options for early may after Kurt talks with a few other potential partners (see item 3).
- 4) Kurt to initiate a talk with Fred Goodwin/ Peter Emmons/ Narendra Gosain to discuss interest in becoming a part of our group.
 - a. Kurt will also call Keith E Kesner to discuss setting up a meeting at ACI –Detroit.
 - a. Kurt will then email Ben/Shannon/Westin about how the discussions went.
 - b. Ben will follow up with Fred/Peter/Narendra/Keith
 - c. Discuss that we are trying to get our own funding.
- 5) Goal for our proposal- Have potential partners list subjects that they are interested in.
- 6) Kurt asked if our research ideas would be appropriate for a CRC proposal.
 - a. Ben says yes and he will send a colleague to ACI Detroit that will see what the requirements are for CRC and what the possibility is of us getting funding.
- 7) Ben will be out of the office until the April 5th.
- 8) Shannon will set up another team call for some time after April 5th.
- 9) We will target to have a large conference call in early May.

Repair Compatibility Research Group Meeting

May 16, 2017

2:00 p.m. - 4:00 p.m. MST

Agenda

1) Invitees:

Name	Organization	Email	On Call?
Shannon Harrell	USBR	sharrell@usbr.gov	X
Westin Joy	USBR	wjoy@usbr.gov	X
Kurt von Fay	USBR	kvonfay@usbr.gov	X
Benoit Bissonnette	Laval University	benoitbissonnette@icloud.com	
Fred Goodwin	BASF	fred.goodwin@basf.com	
Claudio Mannisero	ChemCognition	claudio@chemcognition.com	X
Keith Kesner	CVM Engineers	kkesner3006@gmail.com	
Caroline Talbot	Euclid	ctalbot@euclidchemical.com	X
Dale Bentz	NIST	dale.bentz@nist.gov	X
Clarissa Ferraris	NIST	clarissa@nist.gov	
Jim Preskenis	PremierCPG	JPreskenis@premiermagnesia.com	
Peter Emmons	Structural Group	pemmons@structural.net	X
Igor De la Varga	FHWA	igor.delavarga.ctr@dot.gov	X
Fred Rutz	UC Denver	Fred.Rutz@jrharrisandco.com	X
Carnot Nogueira	UC Denver	carnot.nogueira@ucdenver.edu	X
Robert Moser	USACE-ERDC	robert.d.moser@usace.army.mil	
Michael Sprinkel	VCTIR	Michael.Sprinkel@vdot.virginia.gov	X
Kevin Michols	WJE	kmichols@wje.com	X

2) Compatibility Research Topics

- Dimensional
- Permeability
- Electrochemical (corrosion)
- Chemical
- Aesthetic
- Compatibility and improvements to sustainability

3) Other research topics

4) USBR Topics

- ASR - would alkalis in repair mortar accelerate reaction at the interface and lead to things such as bond failure?
- Shrinkage testing
- Impervious repair mortar with a pervious substrate
 - Measure moisture gradient
 - Potential acceleration of F/T deterioration

5) Partner topics and in-kind contributions

6) ACI involvement?

7) Structure of partnerships, meetings, funding, etc. Board of Directors? Chair?

Meeting Notes

- 1) Shannon Harrell opened the meeting with a brief description of the purpose of the group, short term goals and long term goals, and described the originally proposed compatibility topics.
- 2) It was recommended we establish a common repository for sharing relevant files.
- 3) It was recommended to add adhesion as a research topic.
- 4) UC Denver has recently completed several research efforts and have more ongoing
 - a. Variations in surface roughness treatments, shear strength of bonded overlays
 - b. Surface roughness identical, vary bonding agents, test shear strength of bonded overlays
 - c. Beams, iosopescu testing
 - d. Ultrasonic testing to detect debonding (velocity or amplitude decay)
 - e. Develop shear strength test on cylinders
 - f. PhD study with all of above, proposal to ASTM for testing shear strength of bonded concrete overlays
- 5) Requests were made by some attendees for UC Denver to share their reports.
- 6) Question was posed: Are we talking about repair inlays, overlays, both?
 - a. All types of concrete repairs made with concrete materials.
- 7) Question was posed: What are we trying to solve that we haven't already?
 - a. We have studied and know how to measure and design for dimensional issues.
 - i. ASTM C157 vs Crack Rings vs New Procedures
 - b. We know impermeable placed over permeable and vice/versa can be problematic.
 - c. Data sheet protocol has been published but has not been adopted by manufacturers.
- 8) Research on fresh alkalis introduced via overlays/repairs and effects on ASR has been conducted in Europe.
- 9) Request was made for interested partners to be listed on USBR S&T proposals.
 - a. USBR needs to show interest by other parties to help obtain internal funding
 - b. Proposals are due June 27
 - c. Planned budgets to be spent on upcoming research? This information would be useful to include in USBR proposals
- 10) Interest
 - a. WJE (Kevin Michols) – interested, can participate via in-kind services such as reviewing documents, some testing can be done.
 - b. Claudio Mannisierro – Interested in most of USBR interests. Can serve as bridge between his clients and research partners. Will forward contacts and ideas.
 - c. UC Denver (Fred Rutz) – Can provide fabrication and testing services, can self-fund smaller projects but would need budget for larger projects. Long-term goal would be to develop a standard ASTM test for shear strength at bonded interfaces. Their research is focused on supporting practice.
 - d. VDOT (Michael Sprinkel) – Overlays are of particular concern. Interested in new test methods, including shear test for bonded overlays.
 - e. Kevin Michols - How does shear test correlate to pull-off test? Even if we can't make a good correlation, can we determine a lower-bound shear strength to correlate to pull-off numbers?
- 11) ICRI Concrete Surface Repair Technician (CSRT) Certification
 - a. About 100 people have completed phase 1 and 2.
 - b. Once phase 1 and 2 testing are complete, it takes about 4 weeks to review and award certification.
 - c. Start specifying this requirement and more contractors will send people to be certified.
- 12) Suggestion to add Shear Test at Bonded Overlay Interface to list of research topics.
- 13) Have we contacted anyone at FAA? They have issues with bonded overlays and patches. Greg Cline?

Action Items

- 1) USBR will work to establish a common repository for file sharing and distribute to the group.
- 2) Add *Adhesion* as a consideration under Dimensional Compatibility. **COMPLETE**
- 3) UC Denver to share recently completed theses to those who expressed interest. **COMPLETE** as of 5/16.
- 4) Add *Shear Test at Bonded Overlay Interface* as a research topic. **COMPLETE**
- 5) Claudio to provide contact information for FAA contact.
- 6) Specify ICRI Concrete Surface Repair Technician (CSRT) Certification in your specifications!
- 7) USBR will continue correspondence and schedule a follow-up meeting (timeframe TBD)

Appendix B – Repair Compatibility Storyboard



Proposed concrete repair research program

Von Fay, Kurt <kvonfay@usbr.gov>

Tue, Jan 10, 2017 at 2:01 PM

To: Keith Kesner <kkesner3006@gmail.com>, Ann Harrer <aharrer@wje.com>, Chris Brown <cbrown@conproco.com>, Claudio Manissero <claudio@chemcognition.com>, Fred Goodwin <fred.goodwin@basf.com>, Jim Preskenis <jpreskenis@premiercpg.com>, John L Hausfeld <hausfeldj@bakerconcrete.com>, Kevin Michols <kmichols@wje.com>, Liying Jiang <ljiang@sgh.com>, "Michael M. Sprinkel" <Michael.Sprinkel@vdot.virginia.gov>, Michel Lessard <m.lessard@euclidcanada.com>, Narendra Gosain <ngosain@walterpmoore.com>, Paul E Gaudette <pgaudette@wje.com>, Peter Emmons <pemmons@structural.net>, Pierre Hebert <phebert@mapei.com>, Randal M Beard <rbeard@walterpmoore.com>, Richard Morin <rmorin@ville.montreal.qc.ca>, Robert D ERDC-GSL-MS Moser <robert.d.moser@usace.army.mil>, Timothy RW Gillespie <gillespie.tim@us.sika.com>
Cc: Benoit Bissonnette <benoit.bissonnette@gci.ulaval.ca>, "Harrell, Shannon" <sharrell@usbr.gov>, Westin Joy <wjoy@usbr.gov>, Janet White <jwhite@usbr.gov>

On behalf of the University of Laval and the Bureau of Reclamation, I would like to invite you to participate in a planning session to develop a research initiative to determine solutions to compatibility issues with concrete repairs.

Proposed Repair Compatibility Research Group

Purpose of the Group: The durability of repaired concrete structures and their useful service life depends on many factors. One of the critical factors for long service life concrete repairs is the achievement of compatibility between the repair material and concrete substrate. Compatibility issues have for years been very much of a theoretical concept of concrete repair engineering.

Despite the number of publications on durability and service life of repaired concrete structures, fundamental discussion and guidance on compatibility issues are still lacking. The opinions and recommendations issued on the subject are in some cases confusing, misleading or incorrect, regrettably leading to fallacies about repair compatibility in the practicing community.

This research effort is aimed to resolve some critical issues concerning the compatibility of concrete repair composite systems. There are many ambiguities and misconceptions in the current understanding of fundamental compatibility considerations in concrete repairs.

There are 5 compatibility factors that were outlined in Reclamation Report No. MERL-2014-87 Compatibility Issues in Design and Implementation of Concrete Repairs and Overlays: dimensional, permeability, electrochemical, chemical, and aesthetic (Vaysburd, Bissonnette, von Fay, 2014). The proposed purpose of the task group is to work together to develop a coordinated research initiative to address these compatibility issues, with the intent of providing guidance to engineers and designers to prevent incompatibility related repair failures. We strongly believe that the results of this partnership will lead to valuable information that will contribute to improving the ACI 562-16, "Code Requirements for Assessment, Repair, and Rehabilitation of Existing Concrete Structures and Commentary" and ultimately help implementing tools such as ICRI 320.3, "Guideline for Inorganic Repair Material Data Sheet Protocol" and ACI 364.3R-09, "Guide for Cementitious Repair Material Data Sheet".

We are reaching out to prospective partners to gauge interest in forming a partnership to conduct research and development in this area. We are hoping to have partners from the public sector, private sector and academia. With sufficient interest, we plan to develop research proposals that will be coordinated with the various partners, in accordance with their respective interest and involvement. Based on the amount of interest we get, we would like to reinstate repair workshops, as conducted prior to the Vision 2020 era, which would define the research, coordinate the research effort, and disseminate the information.

We are interested in starting discussions with experts from industry, academia, and government agencies to answer the questions listed below. These questions are preliminary and are intended to serve as a basis for discussion. We expect interested parties to add to the intermediate and ultimate goals during future meetings.

Proposed Intermediate Goals:

1. Identify the current level of knowledge about the five main compatibility issues listed above and determine where significant gaps exist; these gaps would serve as the focal point for further investigations.
2. Are there any other compatibility factors that have not been identified and documented?

3. What research efforts need to be conducted to provide needed design & construction guidelines to properly address compatibility issues?

Proposed Ultimate Goal:

1. Develop guidelines to achieve compatibility in concrete repairs and overlays that would be practical for engineers and contractors to use.
2. Incorporate guidelines into standard concrete repair specifications so that the findings from these studies can be implemented into field practice.

Please let us know if you are interested in participating and if you know of anyone else that would be interested in working on this issue. We look forward to hearing from you soon and plan to call you in a few weeks to get your thoughts about this initiative.

Thank you

Westin Joy, P.E.
Concrete, Geotechnical, and Structural Laboratory
Bureau of Reclamation
303-445-2382

