State of Wisconsin/Department of Transportation

RESEARCH PROGRESS REPORT FOR THE QUARTER ENDING: Mar 31, 2003

Program: SPR-0010(36) FFY99	**Part: II Research and Development**
Project Title: Structural Analysis of Sign Bridge Structures and Luminaire Supports	**Project ID:** 0092-00-16
Administrative Contact: Nina McLawhorn	**Sponsor:**
WisDOT Technical Contact: Error! Bookmark not defined.	**Approved Starting Date:** May 3, 2000
Approved by COR/Steering Committee: $49,969.00	**Approved Ending Date:** Nov 28, 2003
Project Investigator (agency & contact): Christopher Foley: Marquette University	

Description: The study will be conducted over 34 months, and will include 13 tasks completed in four (4) phases.
Phase I: Wind Loading and WI DOT Inspection Procedures
Task 1: Obtain and Review Records/Data
Task 2: Transform Computed Static Wind Pressure Data
Task 3: Synthesize/Scruntinize Research Results for Proposed Research
Task 4: Crack Detection Feasibility Study
Phase II: Luminaire Support Research
Task 5: Re-examination of Failure Investigation Findings
Task 6: Synthesize Results of Past Research
Task 7: Revisit Wind Velocity Relationship to Luminaire Support Failure
Task 8: Develop Inspection Protocols
Phase III: Overhead and Cantilevered Sign Bridges
Task 9: Data Investigation/Analysis
Task 10: Field Visits
Task 11: Qualitative Estimates of Actual and Proposed Data
Task 12: Failure Investigations and Replacement Strategies
Task 13: Experimental Testing
Phase IV: Research Report to WI DOT

Background:
The scope expected for the research can be broken down into two parts. With reference to luminaire supports, the research will seek to develop inspection guidelines to assess the need for replacement and/or retrofit of both high-mast and standard luminaire supports. The research related to sign bridge structures should address the following: (a) determination of the causes of the stress cracking in the sign bridge elements; and (b) an attempt to correlate stress-crack severity and/or location to structural integrity. Specific sign bridges to be considered are included at the end of this problem statement. The results of (a) and (b) should be used to develop inspection criteria for the determination of retrofit and/or replacement of the structure. Finally, the sign bridge research should address the effect of the T-stub truss bridge support retrofit detail on future performance of the modified truss bridge.

Total Study Budget	Current FFY Budget	Expenditures for Current Quarter	Total Expenditures to Date	Percent Complete
$49,969.00	**$9,993.80**	$0.00	**$25,646.74**	**0 (%)**

Error! Bookmark not defined.

Progress This Quarter:
(Includes project committee mtgs, work plan status, contract status, significant progress, etc.)
Since the last quarterly report (progress through 12/28/03), work on the experimental component of the research has continued. An unfortunate circumstance came up regarding the material that was provided for the experimental specimens denoted as MTS-1 through MTS-12 as described in the last quarterly report. The A513B DOM material (in lieu of A500 or A53 material) was initially thought to result in negligible difference in the fatigue performance. However, subsequent material and fatigue performance analysis has suggested that new specimens be fabricated and tested. The rationale for this is described in the following.

The 12 specimens initially provided for the welded joint fatigue testing was A513B DOM (drawn over mandrel). Three material characterization tests performed after the specimen testing yielded the following. Examination of the material under the microscope revealed significant "banding" of the material (most likely created during the drawing process over the mandrel – DOM). This banding in the material's microstructure led to stress-strain behavior that was uncharacteristic of structural steel materials (see Figures 1 and 2 below).

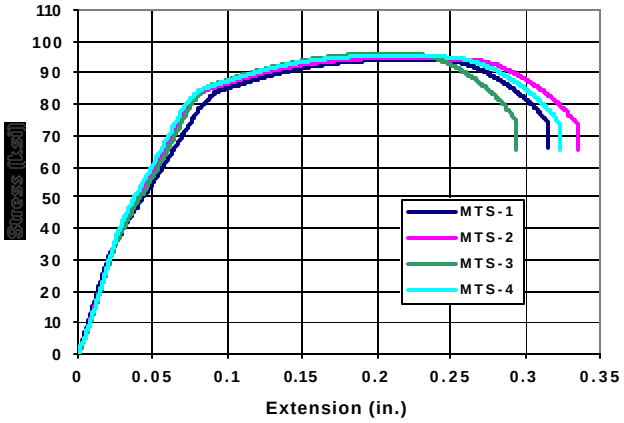


Figure 1: Tensile Test Results for A513B DOM Steel Material.

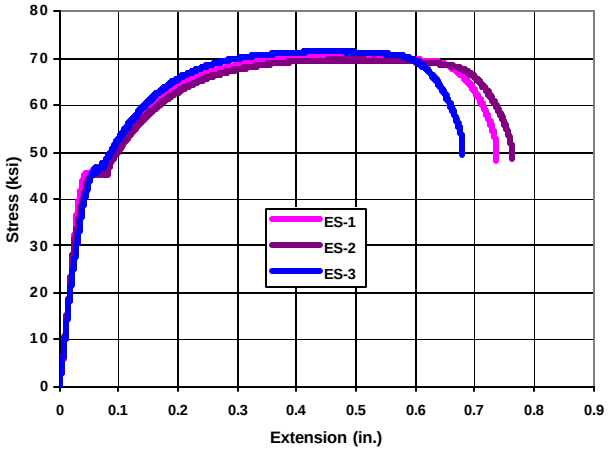


Figure 2: Tensile Test Results for A53 Gr. B Steel Material.

The banding in the material (at the microstructure level) is most likely the cause for the significantly different stress-strain behavior and material toughness indicated in Figures 1 and 2. From a fatigue performance point of view it can be surmised that the material in Figure 1 will have a reduced fatigue life once cracking initiates resulting from the significant reduction in toughness (refer to extension magnitudes). The ability of the material in Figure 1 to deform in a ductile manner at a crack front is significantly lessened due to material banding. Chemical composition analysis of the materials also indicated that the A500 or A53 material was not provided.

The experimental S-N results (quarterly report for period ending 12/31/2002) were also compared with European (IIW/CIDECT) predictive equations. The MTS specimens (material shown in Figure 1) had an average fatigue life of ~17,000 cycles. The IIW/CIDECT equations predict somewhere between 16,500 and 30,000 cycles. Thus, the experimental data appears on the lower bound of the prediction equations. However, the ES specimens (material shown in Figure 2) exhibited an average fatigue life of approximately 133,000 cycles. The IIW/CIDECT equations predict somewhere between 72,000 to 130,000 cycles. The ES specimens were therefore on the upper-end of the predictions.

As a result, the decision to forego additional testing of A500 or A53 Gr. B material for the fabricated specimens was reversed. Based upon the analysis described above, I requested that another eight specimens be fabricated from A53 Gr. B material. Fortunately, my very good friends at Construction Supply and Erection agreed to provide us with the additional specimens at no cost. These specimens are now in the Laboratory, but our fatigue testing will need to take place in May due to laboratory scheduling and some minor fixturing activity.

Progress has been made on the portions of the Report to WisDOT related to the sign support structural analysis and fatigue life prediction and also the high-mast luminaire support studies. Unfortunately, with the academic year winding to a close, these items have yet to be completed.

Work Next Quarter:

Fatigue testing on the eight replacement specimens will take place during this quarter. The results of this testing will form the basis for the MS thesis of Mr. John Peronto who will graduate from Marquette University this summer. This phase of the research will be included in the third part of the WisDOT report.

The work on the HML portion of the report will continue and a draft of the Report for this phase will be forthcoming.

The sign support analysis portion of the research effort is the MS thesis of Mr. Scott Ginal. His MS thesis defense is expected.

Circumstances affecting progress/budget:

There is one item to address regarding budget issues. The Project was granted an extension by WisDOT and it was decided to have spending towards the Project end on February 28, 2003. With the delay in getting the new specimens fabricated, we were unable to cut out specimens for chemical composition analysis until after this date. Chemical composition analysis of these new specimens is needed to ensure widespread acceptance of the experimental data.

Anderson Laboratories performed the previous chemical composition work in an expedient, accurate and professional manner. We have additional material characterization specimens created and are ready to have them analyzed by the laboratory, but our MU account is frozen due to the projected ending date of Feb. 28, 2003. The amount of money required for the chemical composition analysis is $300. There is money in the budget to run the tests, but Marquette will not free this money until the WHRP is notified that the money will be spent after the previously stated project end date (Feb. 28, 2003).

Therefore, the following is requested. Can the WHRP formulate a letter to the Marquette University Office of Research and Sponsored Programs stating that they understand that the Anderson Laboratory chemical composition testing will be done after the Feb. 28, 2003 date and the Invoice can be paid from the Project budget?

Gantt Chart:
Since replacement testing and report writing is being conducted, there is no GANTT chart data worth reporting.

Note: Gantt chart shown in State Fiscal Year Quarters

State of Wisconsin/Department of Transportation

RESEARCH PROGRESS REPORT FOR THE QUARTER ENDING: Mar 31, 2003

Program: SPR-0010(36) FFY99	**Part: II Research and Development**
Project Title: Rehabilitation Techniques for Concrete Bridges	**Project ID:** 0092-01-06
Administrative Contact: Nina McLawhorn	**Sponsor:**
WisDOT Technical Contact: Error! Bookmark not defined.	**Approved Starting Date:** Jan 18, 2001
Approved by COR/Steering Committee: $124,968.00	**Approved Ending Date:** Sep 18, 2003
Project Investigator (agency & contact): Habib Tabatabai: UW-Milwaukee	

Description: This study will be conducted over 18 months, and will be completed in five (5) phases.
Task A: Literature Search
Task B: Testing and Software Development Plan
Task C: Laboratory Testing & Software Development
Task D: Field Demonstration and Evaluation
Task E: Report

Background:
Research Project Description
Concrete bridges in Wisconsin and elsewhere have shown severe signs of deterioration due to aging and other detrimental factors. Considering the enormous cost and effort required to remedy bridge deficiencies, it is crucial that a concerted effort be made to develop and implement practical, effective and economical methods and guidelines for the repair and rehabilitation of bridges. These methods should include effective preventative maintenance measures to reduce the impact and severity of long-term deterioration. This proposal addresses repair and rehabilitation techniques and guidelines for reinforced and prestressed concrete bridges in the state of Wisconsin.

RFP Statement
With the aging of Wisconsin's concrete bridges, increasing evidence of partial or extended bridge deterioration is experienced throughout the state. Problems such as failure of expansion joints, deterioration of concrete at the vicinity of joints and abutments, corrosion of reinforcing and prestressing steel, damage to overhead beams/girders due to truck impact, and other effects exist and need to be corrected on a daily basis. It would be beneficial to the WISDOT maintenance personnel to develop guidelines and procedures for implementing cost effective and reliable rehabilitation techniques to bring Wisconsin's concrete bridges to acceptable service conditions. Performing a study to evaluate various rehabilitation methods developed and implemented elsewhere as well as further development of additional techniques to address specific problems related to Wisconsin's concrete bridges could enhance the economy and safe use of our bridges in the state.

Total Study Budget	Current FFY Budget	Expenditures for Current Quarter	Total Expenditures to Date	Percent Complete
$124,968.00	**$41,656.00**	$0.00	**$120,932.83**	**90 (%)**

Error! Bookmark not defined.

Progress This Quarter:
(Includes project committee mtgs, work plan status, contract status, significant progress, etc.)
The monitoring of test beams continued. Significant progress was made in writing of the final report and the development of software. In the last progress report, the research team requested a six-month no-cost extension of the contract. This was due to the fact that during the repair process when some concrete was removed, it was noted that corrosion had not yet sufficiently progressed into the strands, and increased exposure area and time would be required. The research team has not yet been notified of the status of that request. The research team is preparing its final report with the objective of adding the final data and dissection observations to the report when the extended exposure time has elapsed.

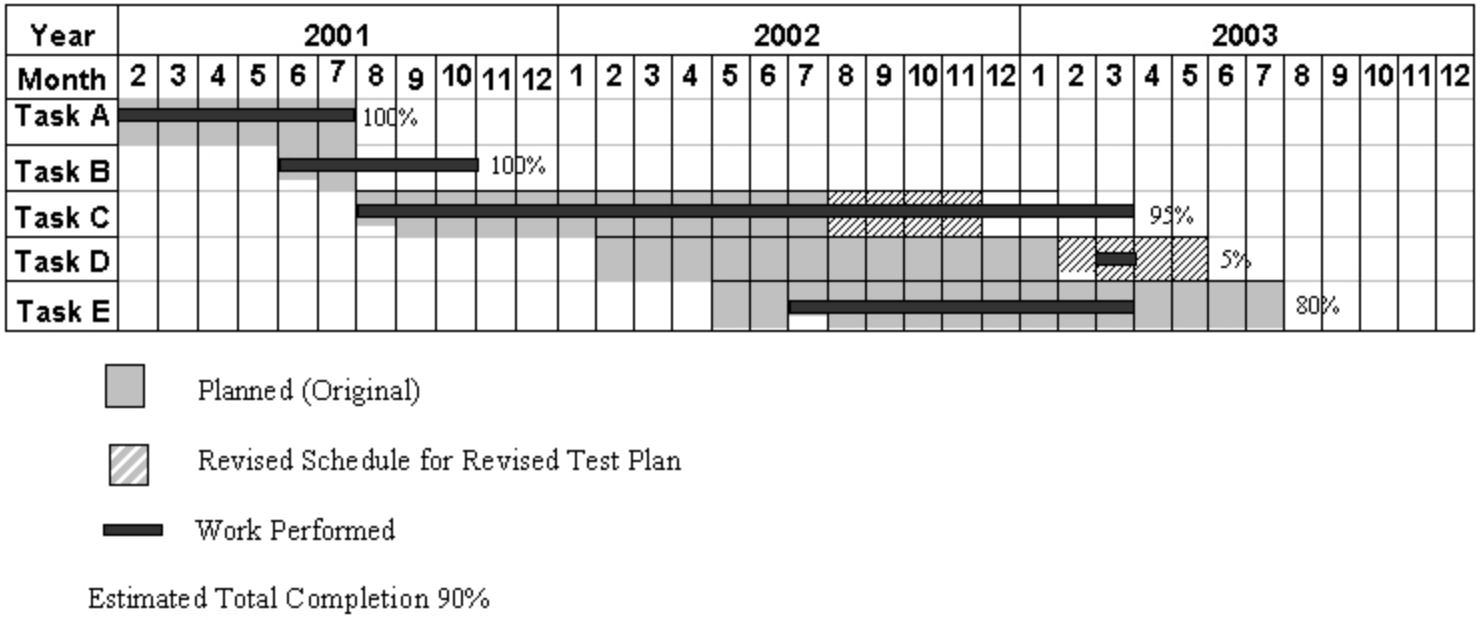
The research team would also like to request that the Wisconsin Department of Transportation identify bridge candidates for the planning of field demonstrations. Ideal candidates would consist of two new and similar (preferably identical) prestressed girder bridges that are going to be built at the same time in close proximity of each other (on the same highway). It is requested that planning and allowance be made in the contract drawings for localized surface treatments of the beam-ends in one of these bridges using one of the methods that are

currently under investigation. The other bridge would serve as the control bridge. The research team will identify and specify the preferred treatment for inclusion in the construction contract based on the final results and in consultation with WisDOT. A suitable long-term monitoring plan will also be suggested.

Work Next Quarter:
Monitoring of test beams will continue. The final report and software, minus data and conclusions that are yet to be collected and assessed, will be completed. Discussions with WisDOT regarding field demonstration efforts will continue.

Circumstances affecting progress/budget:
A request for a no-cost, 6-month time extension was made in the last progress report. This was due to limited observed corrosion during the repair process when some concrete was removed. The additional time would allow further corrosion to occur.

Gantt Chart:



Note: Gantt chart shown in State Fiscal Year Quarters

State of Wisconsin/Department of Transportation

RESEARCH PROGRESS REPORT FOR THE QUARTER ENDING: Mar 31, 2003

Program: SPR-0010(36) FFY99	**Part: II Research and Development**
Project Title: Rapid Strengthening of Reinforced Concrete Bridges	**Project ID:** 0092-02-14b
Administrative Contact: Nina McLawhorn	**Sponsor:**
WisDOT Technical Contact: Stan Woods	**Approved Starting Date:** Nov 7, 2001
Approved by COR/Steering Committee: $59,069.00	**Approved Ending Date:** Aug 31, 2003
Project Investigator (agency & contact): Larry Bank: UW-Madison	

Description: This research study will use a new and innovative technique for rapidly strengthening reinforced concrete memebers with fiber reinforced plastic (FRO) strips will be demonstrated in a full-scale application on an existing bridge in the State of Wisconisn. The testing on the bridge will be preceded by a laboratory test program that will be used to determine the unstrengthened capacity of the bridge prior to ultimate load testing.

Total Study Budget	Current FFY Budget	Expenditures for Current Quarter	Total Expenditures to Date	Percent Complete
$59,069.00	**$29,534.50**	$8,216.10	**$47,457.62**	**88 (%)**

Error! Bookmark not defined.

Progress This Quarter:
(Includes project committee mtgs, work plan status, contract status, significant progress, etc.)

1. Testing of Laboratory Beams

Analysis of the laboratory beams tested during the last quarter has been completed. The full details of the analysis will be provided in the final report to the WisDOT. An analytical method has been developed to predict the capacity of the strengthened beams. The method shows good agreement with the test results.

2. Design and Application Procedure

A procedure was developed for design of mechanically fastened (MF) Fiber Reinforced Polymer (FRP) strips for flexural strengthening of concrete. The procedure accounts for the ductile failure mode seen in MF-FRP strengthened concrete. It is similar to the procedure used for epoxy bonded FRP (EB-FRP) systems and follows the ACI design procedure. Full details of the procedure will be provided in the final report. An application procedure has been developed that describes the equipment, materials and methods to be used for installing the MF-FRP strengthening system.

3. Long-Term Durability Study

An inspection of the strengthened bridge was conducted in mid-March (March 16, 2003) after the end of the winter snow and ice season. This was approximately 6 months (190 days) after installation of the system. Photographs of the condition of the MF-FRP strengthening system were taken to record any change in condition of the system. Overall the MF-FRP system appears to be functioning well and no delaminating of the FRP strips was seen. There appears to be some corrosion of the steel fasteners relative to the stainless steel fasteners but this does not appear to have significantly affected the FRP strip. Following the ultimate load test samples will be taken from the strips and tested to determine their residual properties.

4. Preparations for Ultimate Load Testing

The research team has been coordinating with Kim Johnson and the WisDOT regarding the ultimate (failure) load testing of the bridge. The testing has tentatively been scheduled for June 16 – June 27, 2003. The UW team is coordinating with the research team supervised by Prof. Nanni at the University of Missouri-Rolla who will be conducting the full-scale ultimate load test. The capacity of the bridge has been estimated using the analytical methods developed in the research. The research team awaits confirmation from the WisDOT for the test dates in order to finalize the testing plan.

Work Next Quarter:

1. Ultimate Load Test

In the next quarter the ultimate load test preparations and plans will be completed and the testing will be conducted. A report on the ultimate load testing will be complied for inclusion in the project final report.

Circumstances affecting progress/budget:

The research team needs to get final confirmation that the ultimate load testing can be conducted in the dates proposed. This confirmation needs to be provided as soon as possible so that plans for the testing can be completed. If the testing does not take place in the time period envisioned then the research project schedule will be adversely impacted for remainder of the summer.

Gantt Chart:

	2001-2002											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	Q1			Q2			Q3			Q4		
1. Advisory Committee												
2. Prelim Report												
3(a). Bridge Selection												
3(b). Load rating study												
4. Lab Testing												
5. Testing Plan												
6. Field Testing												
7. Data Analysis												
8. Final Report												

	2002-2003											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	Q5			Q6			Q7			Q8		
1. Advisory Committee												
2. Prelim Report												
3 Bridge Selection												
4. Lab Testing												
5(a). Testing Plan												
5(b). Const. Coord.												
6(a). Field Testing												
6(b). Long-term study												
7. Data Analysis												
8. Final Report												

Note: Gantt chart shown in State Fiscal Year Quarters

State of Wisconsin/Department of Transportation

RESEARCH PROGRESS REPORT FOR THE QUARTER ENDING: Mar 31, 2003

Program: SPR-0010(36) FFY99	**Part: II Research and Development**
Project Title: Evaluation of Concrete Deck and Crack Sealers	**Project ID:** 0092-03-09
Administrative Contact: Nina McLawhorn	**Sponsor:**
WisDOT Technical Contact: Error! Bookmark not defined.	**Approved Starting Date:** Jan 31, 2003
Approved by COR/Steering Committee: $91,740.00	**Approved Ending Date:** Jan 31, 2005
Project Investigator (agency & contact): Jose Pincheira: UW-Madison	

Description: This project will be completed over a 24 month period, and conducted in 4 Tasks:
Task 1: Identify and Review Deck and Crack Sealers
Task 2: Laboratory Testing of Selected Products
Task 3: Final Product Assessment and Development of List of Recommended Products
Task 4: Prepare Final Report

Total Study Budget	Current FFY Budget	Expenditures for Current Quarter	Total Expenditures to Date	Percent Complete
$91,740.00	**$30,580.00**	$0.00	**$0.00**	**10 (%)**

Error! Bookmark not defined.

Progress This Quarter:
(Includes project committee mtgs, work plan status, contract status, significant progress, etc.)
Task 1: Identify and Review of Sealers

Table 1 shows the list of products identified to date. The table includes the list of products approved by the Wisconsin DOT (as of April 2003) as well as those used by some districts as reported on the Structures Maintenance web page of the WisDOT. Ten additional products have been added to the list. It may be noted that there are three deck sealers from TK products (TK-290-WBG, TK-290-WDOT, and TK-290-WDOT E) on the list of approved products, which have been specifically formulated for the Wisconsin DOT. Some districts have used the TK-290 sealants, but at this time it is unclear whether they correspond to the same as those on the approved list.

	DECK SEALERS: WIDOT APPROVED				
	Product Name	**Manufacturer**	**Product Information**	**Date Approved**	**Districts Reporting Use**
1	Aqua-Trete BSM 20	Degussa, Inc.	www.sivento-silanes.con	3/16/2001	
2	Baracade 16 Siloxane			Pre-1999	
3	Eucoguard 100			Pre-1999	
4	Hydrozo Enviroseal 20	Chemrex, Inc.	www.chemrex.com	Pre-1999	
5	Hydrozo Enviroseal 40	Chemrex, Inc.	www.chemrex.com	Pre-1999	
6	Hydrozo Silane 40 VOC	Chemrex, Inc.	www.chemrex.com	3/16/2001	
7	Masterseal SL40 VOC	Premier Sealants & Coatings, Inc.		12/30/2002	
8	Nitecote Dekguard P-40			Pre-1999	
9	Penseal 244 40%	Vexcon Chemical	www.vexcon.com	Pre-1999	
10	Powerseal 40%	Vexcon Chemical	www.vexcon.com	Pre-1999	
11	Sonneborn Penetrating Sealer 40 VOC	ChemRex, Inc.		12/30/2002	
12	Spall-Guard 40	Chemmasters	www.chemmasters.net	3/16/2001	
13	TK-290-WBG	TK Products	www.tkproduct.com	3/16/2001	
14	TK-290-WDOT (or TK-290-16)	TK Products	www.tkproduct.com	Pre-1999	
15	TK-290-WDOT E	TK Products	www.tkproduct.com	3/16/2001	
	DECK AND CRACK SEALERS: NOT WIDOT APPROVED				
16	10 Minute Concrete Mendor	Roadware, Inc.	www.concretemender.com		6
17	Denepox I40	DeNeef Const. Chem.	www.deneef.com		4
18	Denepox I-60				
19	Duraguard 100				
20	Epoxy Injection				7
21	Sikadur 52				
22	Sikadur 55SLV				
23	TK-26 - Gray Pigmented	TK Products	www.tkproduct.com		
24	TK-2617	TK Products	www.tkproduct.com		7
25	TK-290	TK Products	www.tkproduct.com		4,5,6
26	TK-290 Tri-Siloxane	TK Products	www.tkproduct.com		
27	TK-290 WB Tri-Siloxane	TK Products	www.tkproduct.com		
28	TK-9000	TK Products	www.tkproduct.com		6,4
29	TK-9010 Crack & Joint Repair	TK Products	www.tkproduct.com		
30	TK-9020 Crack & Joint Repair	TK Products	www.tkproduct.com		
31	TK-9030 Crack & Joint Repair	TK Products	www.tkproduct.com		

In Table 2, some characteristics of the products listed in Table 1 are shown. The product characteristics considered to date include requirements for the surface preparation and application, coverage rates, expected durability, the time required before the deck can be opened to traffic, cost, and environmental conditions. The last column shows the comments provided by the Districts that have used the product.

CHARACTERISTICS OF SELECTED PRODUCTS

	Product Name	Category	Surface Preparation Requirements	Application Conditions	Coverage Rates	Expected Durability	Time to Open Traffic	Cost	Environmental Conditions	Comments from Districts
1	10 Minute Concrete Mendor									Two part hybrid urethane polymer concrete (with sand)
2	Aqua-Trete BSM 20	water repellant	cleaned via shotblasting, sandblasting, waterblasting, and chemical cleaners	40<T<100 F do not use if T<40 within 12 hours after application, or precip expected within 4 hrs.						
3	Baracade 16 Siloxane									
4	Denepox I40									Epoxy injection, used anywhere on structure; repair cracks in deck
5	Denepox I-60									
6	Duraguard 100									
7	Epoxy Injection									Insert into delaminated deck
8	Eucoguard 100									
9	Hydrozo Enviroseal 20	sealer	must be clean, dry surface is suggested for best performance	T>40 F, do not use if T<40 within 12 hrs.	100-175 sf/gal					
10	Hydrozo Enviroseal 40				100-200 sf/gal					
11	Hydrozo Silane 40 VOC	water repellant							"excellent for cold weather applications"	
12	Masterseal SL40 VOC									
13	Nitecote Dekguard P-40									
14	Penseal 244 40%	sealer	may be damp, power-washed	T>20 F	Older concrete: 95-140 sf/gal					
15	Powerseal 40%	water repellant	must be clean, may be damp	Protect from rain for 4-6 hrs, T>40 F						
16	Sikadur 52									
17	Sikadur 55SLV									
18	Sonneborn Penetrating Sealer 40 Voc									
19	Spall-Guard 40									
20	TK-26 - Gray Pigmented									Public likes visibility of parapets
21	TK-2617									Two part epoxy crack sealer
22	TK-290									Clear on parapets, deck appl. rate approx. 1/2 of manufacturers recommended rate on previously sealed decks. (i.e., 2-300 sq ft/gal.), six month shelf life after opening, siloxane sealer
23	TK-290 Tri-Siloxane									
24	TK-290 WB Tri-Siloxane									
25	TK-290-WBG									
26	TK-290-WDOT (or TK-290-16)									
27	TK-290-WDOT E									
28	TK-9000									Two-part epoxy crack sealer; used to repair cracks in deck
29	TK-9010 Crack & Joint Repair									
30	TK-9020 Crack & Joint Repair									
31	TK-9030 Crack & Joint Repair									

Work Next Quarter:

Additional information. including technical characteristics, such as strength, water absorption, chemical resistance, etc., will be gathered in order to complete Table 2. In addition, bridge maintenance engineers from the Districts will be contacted to obtain additional and more

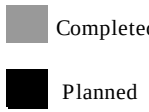
detailed information on their experience using the products. A short survey will be distributed to the Districts for this purpose. Upon collection of the data, the merits and disadvantages of each product will be assessed and a list of candidate products for in-depth study will be recommended. A meeting with the project TOC will be scheduled to discuss the selection of products for in-depth study. Additionally, the set-up and fabrication of specimens for the permeability tests (Task 2) will begin.

Circumstances affecting progress/budget:

Due to delays in the contract agreement and the uncertainty on the starting date of the project, the selection of a qualified research assistant had to be postponed. This resulted in slower progress than planned in this first quarter. A research assistant has now been identified who will begin work by mid May.

Gantt Chart:

Task	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Identify and Review Sealers								
2a.Permeability Tests of Deck Sealers								
2b.(i) Penetration Tests of Crack Sealers								
2b.(ii) Bond Tests of Crack Sealers								
3. Eval. and Develop List of Products								
4. Write Final Report								



Note: Gantt chart shown in State Fiscal Year Quarters