4th Quarterly Progress Report

Ohio DOT Research

Fourth Quarter Ended on December 31, 2018

"Quarterly Report: State Job #31347"

For Quarter Ending:	December 31, 2018
Date Submitted:	**January 31, 2019**

Project Title:	Structural Design Methodology for Spray Applied Pipe Liners in Gravity Storm Water Conveyance Conduits				
Research Agency:	CUIRE/The University of Texas at Arlington				
Principal Investigator(s):	PI: Mohammad Najafi, Ph.D., P.E., F. ASCE, Professor and Director, CUIRE Co-PI: Xinbao Yu, Ph.D., P.E., Associate Professor				
State Job Number:	5501.03		Agreement Number:		31347
Project Start Date:	20 December 2017		Contract Funds Approved:		25 September 2017
Project Completion Date:	20 December 2019		Spent to Date:		$198,562.79
% Funds Expended:	50%	% Work Done:	45%	% Time Expired:	50%

List the ODOT Technical Liaisons and other individuals who should receive a copy of this report:

1. Jeffrey E. Syer, P.E. – Ohio DOT
2. Brian R. Carmody, P.E. – NYSDOT
3. Matthew S. Lauffer, P.E. and Charles Smith P.E. – NCDOT
4. Paul Rowekamp and Aislyn Ryan – MnDOT
5. Sheri Little – PennDOT
6. Carlton Spirio – FDOT
7. Jonathan Karam and Nicholas Dean – DelDOT

Contents

Tables

Figures

Schedule of Research Activities Tied to Each Task Defined in the Proposal and Percentage Completion of the Research

Table 1: SAPL Research Project Schedule

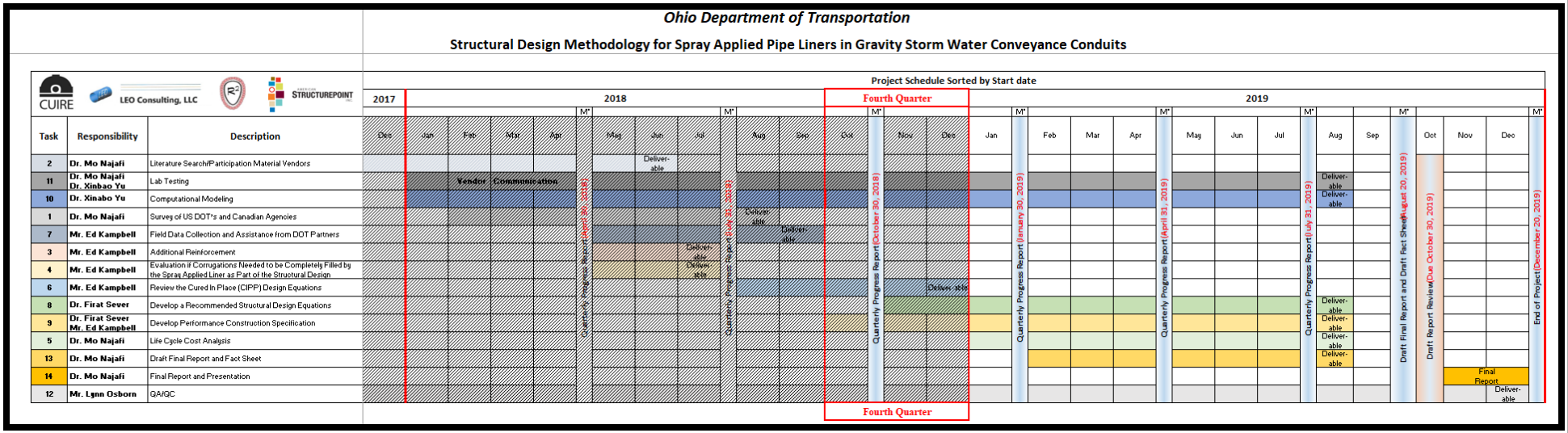

Table 2: Completion Percentage of SAPL Research Project Tasks over the 1st, 2nd, 3rd and 4th Quarters

Structural Design Methodology for Spray Applied Pipe Liners in Gravity Storm Water Conveyance Conduits

Task Number	Task Description	Percentage Completed by the end of 1st Quarter *Dec 2017 through March 2018*	Percentage Completed by the end of 2nd Quarter *April 2018 through June 2018*	Percentage Completed by the end of 3rd Quarter *July 2018 through September 2018*	Percentage Completed by the end of 4th Quarter *October 2018 through December 2018*
1	Survey of US DOT's and Canadian Agencies	29%	71%	100%	100%
2	Literature Search/Participation Material Vendors	57%	100%	100%	100%
3	Additional Reinforcement	0%	67%	95%	100%
4	Evaluation if Corrugations Needed to be Completely Filled by the Spray Applied Liner as Part of the Structural Design	0%	67%	90%	100%
5	Life Cycle Cost Analysis	0%	0%	0%	0%
6	Review the Cured in Place (CIPP) Design Equations	0%	0%	67%	80%
7	Field Data Collection and Assistance from DOT Partners	0%	40%	100%	100%
8	Develop a Recommended Structural Design Equations	0%	0%	0%	20%
9	Develop Performance Construction Specification	0%	0%	0%	0%
10	Computational Modeling	19%	38%	57%	60%
11	Lab Testing	19%	38%	43%	45%
12	QA/QC	17%	29%	38%	54%

Comparative Status of Actual Versus Estimated Expenditures

Table 3: The 4th Quarterly Progress Work of SAPL Research Project

Structural Design Methodology for Spray Applied Pipe Liners in Gravity Storm Water Conveyance Conduits

Task Number	Task Description	Total Duration (Months)	Duration Completed (Months)	Budgeted Amount ($)	Percentage of Completion Based on Schedule (%)	Percentage of Total Budget (%)	Percentage Completed This Quarter (%)	Actual Amount Completed this Quarter ($)
1	Survey of US DOT's and Canadian Agencies	7	7	$25,751	100	6.44	0	0
2	Literature Search/Participation Material Vendors	7	7	$21,875	100	5.47	0	0
3	Additional Reinforcement	3	3	$2,100	100	0.52	100	$2,100
4	Evaluation if Corrugations Needed to be Completely Filled by the Spray Applied Liner as Part of the Structural Design	4	3	$3,900	75	0.97	75	$2,925
5	Life Cycle Cost Analysis	3	Not Started	$29,123	0	7.28	0	0
6	Review the Cured in Place (CIPP) Design Equations	3	2	$13,751	67	3.44	67	9,213
7	Field Data Collection and Assistance from DOT Partners	5	5	$26,752	100	6.69	0	0
8	Develop a Recommended Structural Design Equations	5	1	$34,081	20	8.52	20	$6,816
9	Develop Performance Construction Specification	7	Not Started	$27,392	0	6.85	0	0
10	Computational Modeling	20	12	$52,039	60	13	5	$2,602
11	Lab Testing	20	12	$67,001	60	16.75	5	$3,350
12	QA/QC	24	12	$8,000	50	2.00	13	$1,040
13	Draft Final Report and Fact Sheet	7	Not Started	$88,270	0	22.07	0	0
14	Final Report and Presentation	3	Not Started					
Total				$400,034	-	100	-	$28,046

Table 4: Expenditures Summery of SAPL Research Project in the 4th Quarter

Structural Design Methodology for Spray Applied Pipe Liners in Gravity Storm Water Conveyance Conduits	
Summary of Expenditures for the 4th Quarter (October through December 2018)	
Description	**Sum Amount**
Salaries and Benefits	
Students Salaries and Benefits	$ 15,191.87
Faculty Salaries will be Paid During Summer Months	
Subtotal	$ 15,191.87
Partner Companies	
American Structurepoint, Inc.	$ 1,045.69
Subtotal	$ 1,045.69
Supplies	
Geokon Pressure Cell	$ 9,002.71
Subtotal	$ 9,002.71
Other Direct Costs	
Direct Costs	$ 323.02
Total	**$ 25,563.29**

Brief Description of the Activities Accomplished by Each Member of the Research Team as Listed in the Project Budget

Principal Investigator: Dr. Mohammad Najafi

Task 3: Additional Reinforcement.

- Finalized and submitted SAPL additional reinforcement draft report.

Task 11: Laboratory Testing.

Soil Box Testing.

- 14 CMPs donated by Contech and delivered to CUIRE/UTA on Dec 26, 2018 (Appendix A, Figure A1).
- Stored above CMPs in a safe and secured area (Appendix A, Figure A2).
- Purchased earth pressure cells.
- Prepared final draft of the detailed Soil Box Testing Plan using CMP as follows:
  - Testing configuration.
  - Instrumentation procurement (strain gauges and cable displacement sensors).
  - Actuator procurement.
  - Steel frame procurement.
- Obtained analysis software Strain Smart from MM and installed it on the test computer.
- Prepared and submitted a list of other necessary equipment like batteries, soldering kits, etc. required for instrumentation.
- Taking inventory of the available equipment at CUIRE laboratory.
- Organizing laboratory tools.

Participation in the Meetings during Conferences, Internal Meetings, Progress Meetings.

- Attended four monthly progress meetings with DOTs.
- Held meetings with Contech Engineered Solutions LLC.
- Held internal meetings with CUIRE team research partners (Xinbao Yu, Ed Kampbell, Lynn Osborn, and Firat Sever).
- Submitted one magazine articles (Trenchless Technology) and four conference papers (No-Dig Show and ASCE Pipelines).
- Presented at the International Conference on Pipelines and Trenchless Technology (ICPTT), October 25-26, 2018, Ningbo, China.

Co-Principal Investigator: Dr. Xinbao Yu

The following are the tasks performed this quarter:

1. Soil Box Tests

a) Soil Box Test Plan

- Submitted the gradation requirements for candidate test soils according to ASTM and AASHTO.
- Submitted tech memos for soil type, participating in discussion for cover thickness and type of partition wall.
- Obtained prices of concrete sand from various suppliers.
- Obtained a sample of concrete sand from Big Tex Stones.
- Participating in lab preparation

b) Instrumentation

- Obtained a revised quote from Micro-Measurement (MM) for strain gauges and ancillary instrumentation.
- Obtained analysis software Strain Smart from MM and installed it on the test computer.
- Prepared and submitted a list of other necessary equipment like batteries, soldering kits, etc. required for instrumentation.
- Recalibrated earth pressure cells.

2. FEM Modelling

- Completed the modeling of the intact equivalent CMP.
- Completed and compared the behavior of the invert-cut equivalent CMP with intact CMP.
- Performed preliminary mesh sensitivity analysis of the intact CMP.
  - The mesh sizes that were chosen were 4, 3, 2 and 1 inches.
- Compared the effects of cover thickness on the structural response of invert-cut CMP.
  - The CMP was modeled with 2 ft, 1.5 ft and 1 ft of cover.
- Studied the performance of the invert-cut CMP using the different type of cover material.
  - The top 1 ft layer of the sand was replaced with gravel in both 2 ft, and 1.5 ft cover.

- Studied the ultimate load carrying capacity of the CMP under different loading pad sizes.
    - The loading pad sizes were 10x20 in^2 and 20x40 in^2.
- Completed the geometrical model of CMP in SolidWorks for modeling the actual geometry of CMP.

Subcontractor: Mr. Ed Kampbell
Rehabilitation Resource Solutions, LLC

Task 4 – Evaluation if Corrugations needed to be Completely Filled by the SAPL as Part of the Structural Design

This report was essentially complete as of June 30, 2018 and given to the CUIRE for their review. The comments received by the DOT partners were reviewed and edits were made to the report. I requested assistance from CUIRE to produce moment of inertia calculations for the lining and the host pipe materials to make a statement as to the structural impact of lining the corrugation valleys first and then applying the lining. This information was received on September 28, 2018. I submitted my final draft of the report to CUIRE on December 14, 2018.

Task 6 – Review the Cured in Place (CIPP) Design Equations

This task has been started but postponed until the 1st quarter of 2019.

Subcontractor: Dr. Firat Sever
American Structurepoint, Inc. (ASI)

Subcontractor American Structurepoint, Inc. /Dr. Firat Sever has performed the following tasks in the 4th quarter:

- Attended conference calls with the CUIRE and DOTs.
- Reviewed the lab test plan.
- Identified base design equations for polymeric and cementitious SAPLs.
- Prepared a detailed design equation development approach.
- Prepared a template and completed generic sections for technical specifications (one for polymeric and one for cementitious SAPL).

Subcontractor: Mr. Lynn Osborn
LEO Consulting, LLC

Task 12. QA/QC.

As QA/QC Reviewer, much of my work depends upon the work and progress of other team members and items that require quality checks.

Activities for Q4 include:

- Reviewed field inspection reports for each participating state and final report.
- Reviewed the "Design Equation Development" Document.

Proposed Work for New Quarter

Table 5: SAPL Research Project Tasks for 5th Quarter (January 1 through March 31, 2019)

Structural Design Methodology for Spray Applied Pipe Liners in Gravity Storm Water Conveyance Conduits					
Task Number	**Responsibility**	**Task Description**	**Percentage of Work to be Completed by the end of 5th Quarter**		
			January 1st through March 31st		
			January	**February**	**March**
4	Mr. Ed Kampbell	Evaluation if Corrugations Needed to be Completely Filled by the Spray Applied Liner as Part of the Structural Design	100%	-	-
5	Dr. Mo Najafi	Life Cycle Cost Analysis	-	-	To be Started
6	Mr. Ed Kampbell	Review the Cured in Place (CIPP) Design Equations	-	100%	-
8	Dr. Firat Sever	Develop a Recommended Structural Design Equations	-	To be Continued	
9	Dr. Firat Sever Mr. Ed Kampbell	Develop Performance Construction Specification	To be Continued		
10	Dr. Xinabo Yu	Computational Modeling	To be Continued		
11	Dr. Mo Najafi Dr. Xinbao Yu	Lab Testing	Control Test to be Completed		
12	Mr. Lynn Osborn	QA/QC	To be Continued		

Principal Investigator: Dr. Mohammad Najafi

Task 4: Evaluation if Corrugations needed to be Completely Filled by the Spray Applied Liner as Part of the Structural Design

- Submit draft final report.

Task 5: Life Cycle Cost Analysis

- Start life cycle cost analysis.

Task 11: Soil Box Testing

- Purchase embedment soil.
- Purchase instrumentation including strain gauges, cable displacement sensors and accessories.
- Arrange a workshop for Micro-Measurement.
- Soil box testing of control test.
- Install steel framing.
- Install actuator.

Presentation

- Will present a paper at No-Dig Show in Chicago, March 17-21, 2019.

Co-Principal Investigator: Dr. Xinbao Yu

Planned Task for the Next Quarter

- Evaluation of embedment soil.
- Control tests on bare CMP.
- FEM modeling of CMP using actual (corrugated geometry).

Subcontractor: Mr. Ed Kampbell
Rehabilitation Resource Solutions, LLC

Task 6 – Review the Cured in Place (CIPP) Design Equations

The report on the review of how CIPP is designed was shown to be done by the end of October. I postponed finishing this report because I wanted to incorporate information about the new ASCE Manual of Practice that was being reviewed at that time by the Blue Ribbon Review Panel (BRRP), which was supposed to conclude their work around the end of November. Unfortunately, the BRRP has still not delivered their comments to me. Per CUIRE's directions, I plan on completing this task by Friday, January 25th. You should note, however, that at the TRB there was quite a bit of discussion about these issues with the F1216's Design Appendix and Jeff Syar was noticeably concerned with Ian Moore's comments. I will try and convey what was said technically in the upcoming Task 6 Report.

Task 9 – Develop Performance Construction Specifications

A draft performance specification will be developed for; (1) polymeric sprayed applied pipe liners and (2) cementitious sprayed spray applied pipe liners. Due to the need to collaborate with others, completion of this task is postponed to August 2019.

Subcontractor: Dr. Firat Sever
American Structurepoint, Inc. (ASI)

- Continue on identifying more base equations.
- Modify the current base equations based on experimental data and computational modeling with FEA being performed by CUIRE.
- Coordinate ASI tasks with respect to design equations and technical specifications development.
- Improve the draft specifications, particularly with respect to developing procedures for QA/QC.
- Attend periodic team conference calls (internal).
- Review any interim work and reports.

Subcontractor: Mr. Lynn Osborn
LEO Consulting, LLC

Task 12. QA/QC.

QA/QC reviews will continue on design and development planning, inputs and control. This will include general project oversight as required.

Implementation (if any):

N/A

Problems & Recommended Solutions (if applicable):

Due to additional inspection sites and changes in the soil box testing plan, additional time and cost will be submitted.

Equipment Purchased (if any):

N/A

Contacts and Meetings

Progress Meeting

Table 6: SAPL Progress Meeting during the 4th Quarter
October 1 through December 31

No.	Progress Meeting Agenda	Date
9	• Schedule Update • Task 11 - Soil Box Testing Plan – Discussion on Comments: - Update - Instrumentation	October 9, 2018
10	• Schedule Update • Soil Box Testing o New Steel Frame o New Actuator (330 kips) o CMP Delivery Date • According to current schedule, 3 months expected for each Soil Box Test	November 13, 2018
11	• Schedule Update • Soil Box Testing o New Steel Frame o New Actuator Delivery Date o CMP Delivery Date • Data Base • Minutes of Special FEA Meeting on December 7	December 11, 2018

Appendix A

(CMP Photos)

(a)

(b)

(c)

(d)

Figure A1: CMPs Donated by Contech (Delivered to CUIRE/UTA on December 26, 2019)

Figure A2: Stored above CMPs in a Safe and Secured Area

Figure A3: CMPs Invert Cut Detail