

Quarterly Progress Report:

Project Number and Title: 2.11 Culvert Rehabilitation using 3D Printed Diffusers

Research Area 2: New materials for longevity and constructability

PI: *Roberto Lopez-Anido, University of Maine*

Co-PI(s): *James Anderson and Douglas Gardner, University of Maine*

Reporting Period: *01/01/2021 to 03/31/2021*

Date: *06/30/20*

Overview:

Main activities in this quarter were:

- Plan lab testing and material characterization
- Prepare conference paper presentation
- Plan demonstration project with Technical Champion and NHDOT engineers.

Meeting the Overarching Goals of the Project:

The activities performed in this quarter supported the following project tasks:

- Task 1: Initial feasibility study: Design and manufacturing of a 3D printed diffuser prototype for demonstration at a site in Thorndike, Maine
- Task 2: Manufacturing of 3D printed diffuser parts for lab testing and material characterization

Accomplishments:

- **Durability problem:** When corroded culverts are re-lined, then the flow is restricted.
- **Hydraulic solution:** Culvert outlet diffusers can increase the flow by 40%, mitigating roads washing-out after storms.
- **Engineering innovation:** Large scale 3D printing technology enables rapid manufacturing of complex shaped culvert diffusers based on site-specific hydraulic conditions at half the cost than current methods, using bio-based materials.
- **Transportation benefits:** Increasing the drainage flow in culvert relining projects by 40%, avoids millions of dollars spent in complete culvert bridge replacements.
- **Technology implementation:** First 3D printed culvert outlet diffuser to be installed in Maine this summer.

Task Progress and Budget:

Table 1: Task Progress			
Task Number	Start Date	End Date	% Complete
Task 1.1: Initial feasibility study: Design and manufacturing of a 3D printed diffuser prototype for demonstration at a site in Thorndike, Maine	9/1/2020	12/31/2020	100%
Task 1.2: Manufacturing of 3D printed diffuser parts for lab testing and material characterization	10/1/2021	8/31/2020	30%
Task 1.3: Material durability evaluation in the laboratory	1/1/2021	8/31/2021	15%
Task 2.1: Monitoring of the 3D printed diffuser at the site in Thorndike, Maine	10/1/2021	6/30/2022	0%
Task 2.2: Develop design concepts for 3D printed diffuser systems (Options 1, 2 & 3)	7/1/2021	8/31/2022	0%
Task 2.3: Commercialization and documentation of the rehabilitation technology	10/1/2021	8/31/2022	0%
Phase 1 Overall	9/1/2020	8/31/2021	Phase 1 % Complete
Phase 2 Overall	7/1/2021	8/31/2022	Phase 2 % Complete

Table 2: Budget Progress		
Project Budget	Spend – Project to Date	% Project to Date*
Enter Phase 1 Full Budget	Enter Phase 1 Full Spend Amount	Enter Phase 1 % Spent
Enter Phase 2 Full Budget	Enter Phase 2 Full Spend Amount	Enter Phase 2 % Spent

*Include the date the budget is current to.

Professional Development/Training Opportunities:

N.A.

Technology Transfer:

Schedule second meeting with NHDOT engineers and Alex Mann (Technical Champion) to plan the design and manufacturing of outlet diffuser for CMP liner and inlet upgrade project, NH 85/Newfields Rd, Exeter - Rocky Hill Brook.

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events				
Title	Event	Type	Location	Date(s)
Large-Scale Extrusion-Based 3D Printing for Highway Culvert Rehabilitation	SPE-ANTEC 2021 Conference	Presentation by Sunil Bhandari, Ph.D. Candidate	Virtual event	May 10, 2021
https://www.4spe.org/i4a/pages/index.cfm?pageID=6478				
Bio-based 3D printed culvert diffusers to reduce roadway storm damage	Hearing on the Climate Resiliency Within the Transportation Industry. Testimony of Dr. Habib J. Dagher, PE	Testimony Before the Subcommittee on Transportation, Housing and Urban Development, and Related Agencies, Committee on Appropriations	Senate Office Building, Washington, DC	May 13, 2021
https://www.appropriations.senate.gov/hearings/rethinking-disaster-recovery-and-resiliency-part-i-protecting_our-nations-transportation-systems				
Culvert Rehabilitation using 3D Printed Diffusers	TIDC Showcase Presentation	Presentation by Sunil Bhandari, Ph.D. Candidate	Virtual event	May 19, 2021
https://www.tidc-utc.org/events/showcase-presentations/may-2021/				

Table 4: Publications and Submitted Papers and Reports				
Type	Title	Citation	Date	Status
Conference Paper	Large-Scale Extrusion-Based 3D Printing for Highway Culvert Rehabilitation	Bhandari, S., Lopez-Anido, R.A., Anderson, J. and Mann, A. "Large-scale extrusion-based 3D printing for highway culvert rehabilitation," ANTEC 2021, Classic, SPE Inspiring Plastics Professionals, Hybrid Edition, May 10, 2021.	May 10, 2021	Published



Figure 1: printed culvert diffuser (8.5 ft long, 2.5 ft wide) will be installed by Maine DOT to test protection against flooding.

Participants and Collaborators:

Table 5: Active Principal Investigators, faculty, administrators, and Management Team Members			
Individual Name	Email Address	Department	Role in Research
Roberto Lopez-Anido	RLA@maine.edu	UMaine Civil and Environmental Engineering	Project PI, Graduate student supervisor, and Structural design and material durability lead.
James Anderson	James.m.anderson@maine.edu	UMaine Advanced Structures and Composites Center	Co PI, Large-scale 3D printing lead
Douglas Gardner	douglasg@maine.edu	UMaine School of Forest Resources	Co PI, Extruded material formulation lead.

Table 6: Student Participants during the reporting period				
Student Name	Email Address	Class	Major	Role in research
Sunil Bhandari		Ph.D. Candidate	Civil Engineering	Structural design and modeling, 3D printing process design and implementation
Felipe Saavedra		M.S. student	Civil Engineering	Material durability evaluation in the laboratory

Table 7: Students who Graduated During the Reporting Period			
Student Name	Degree	Graduation Date	Employment or continued degree

Table 8: Research Project Collaborators during the reporting period						
Organization	Location	Contribution to the Project				
		Financial Support	In-Kind Support	Facilities	Collaborative Research	Personnel Exchanges
Maine DOT	Augusta, ME	x	x		x	

Table 9: Other Collaborators

Collaborator Name and Title	Contact Information	Organization and Department	Contribution to Research
Timothy S. Mallette, P.E.		NHDOT Specialty Section, Hydraulics	Identified demonstration project and coordinated planning meeting
Don LeBlanc, P.E.		President DLVEWS, Inc.	Culvert design consultant

Technical Champion:

Name: Alexander Mann

Title: Hydrologist

Organization: MaineDOT

Location (City & State): Augusta, ME

Email: Alexander.Mann@maine.gov

Changes:

The schedule has been affected by disruptions of day-to-day campus and field work due to the University restrictions imposed in response to COVID-19 health safety precautions.

Planned Activities:

The following activities are planned for the next three month period:

- Manufacture 3D printed diffuser parts/plates for laboratory testing and material characterization (Task 2)
- Review the literature and guidelines on environmental durability evaluation of thermoplastic composite materials for large-scale 3D printing (Task 3)
- Select accelerated durability testing protocols in the laboratory (Task 3)
- Identify potential demonstration projects for culvert diffusers in collaboration with MaineDOT (Task 5)