Quarterly Progress Report:
Project Number and Title: Project 2.4 - Thermoplastic Composites by 3D Printing and Automated Manufacturing to Extend the Life of Transportation Facilities
Research Area: 2 - New Materials for Longevity and Constructability
PI: *Roberto Lopez-Anido, University of Maine*
Co-PI(s): *James Anderson, Douglas Gardner and Yousoo Han, University of Maine*
Reporting Period:*10/01/2019 to 31/12/2019*
Submission Date: *31/12/2019*

Overview: (Please answer each question individually)

*Provide **BRIEF** overview and summary of activities performed during the reporting period. This summary should be written in lay terms for a general audience to understand. This should not be an extensive write up of findings (those are to be included in the final report), but a high-level overview of the activities conducted during the last three months….*
Organized a teleconference with PCI-NE regarding use of 3D printed forms in transportation infrastructures.
Organized a meeting regarding the use of 3D printed formwork for precast concrete. Attendees of the meeting were concrete precasters, cement manufacturers, PCI-NE, and MaineDOT. Discussed several challenges and opportunities regarding use of 3D printed bio-based forms for casting precast concrete. As a follow-up of this meeting, Superior Concrete expressed interest in using 3D printed forms for casting a pier-cap using 3D printed forms.

Provide context as to how these activities are helping achieve the overarching goal(s) of the project…
These meetings and teleconferences helped us identify bridge pier cap as a suitable demonstration project for 3D printed forms.

Describe any accomplishments achieved under the project goals…

Complete the following tables to document the work toward each task and budget (add rows/remove rows as needed)…

Table 1: Task Progress

Task Number	Start Date	End Date	Percent Complete
Task 1: Review of the state-of the-art	01/01/2019	11/30/2019	100%
Task 2: Optimize forms and tooling for selected precast concrete part	12/01/2019	05/01/2020	20%
Task 3: Select materials and manufacturing process	02/01/2020	07/01/2020	0%
Task 4: Demonstrate the 3D printing tooling for a project	04/01/2020	08/31/2020	0%
Task 5: Recycle and reprint the tooling material	09/01/2020	08/31/2021	0%

Table 2: Budget Progress

Entire Project Budget	Spend Amount	Spend Percentage to Date
$149,912	$54,936	36.6% (12/31/2019)

Describe any opportunities for training/professional development that have been provided…
Attended PCI CEU course webinar on 3D printed forms for use in architectural precast concrete.

*Describe any activities involving the dissemination of research results (be sure to include outputs, outcomes, and the ways in which the outcomes/outputs have had an impact during the reporting period. Please use the tables below for any Publications and Presentations in addition to the description of any other technology transfer efforts that took place during the reporting period.)… Use the tables below to complete information about conferences, workshops, publications, etc**. List all other outputs, outcomes, and impacts after the tables** (i.e. patent applications, technologies, techniques, licenses issued, and/or website addresses used to disseminate research findings).*

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events				
Title	**Event**	**Type**	**Location**	**Date(s)**
N/A				

Table 4: Publications and Submitted Papers and Reports				
Type	**Title**	**Citation**	**Date**	**Status**
Peer-reviewed journal	Enhancing the interlayer tensile strength of 3D printed short carbon fiber reinforced PETG and PLA composites via annealing	Bhandari, S., Lopez-Anido, R.A. and Gardner, D.J., 2019. Enhancing the interlayer tensile strength of 3D printed short carbon fiber reinforced PETG and PLA composites via annealing. Additive Manufacturing, 30, p.100922.	November 2019	Accepted
Peer-reviewed journal	Elasto-Plastic Finite Element Modeling of Short Carbon Fiber Reinforced 3D Printed Acrylonitrile Butadiene Styrene Composites	Bhandari, S., Lopez-Anido, R.A., Wang, L. and Gardner, D.J., 2020. Elasto-Plastic Finite Element Modeling of Short Carbon Fiber Reinforced 3D Printed Acrylonitrile Butadiene Styrene Composites. JOM, 72(1), 475-484	November 2019	Accepted

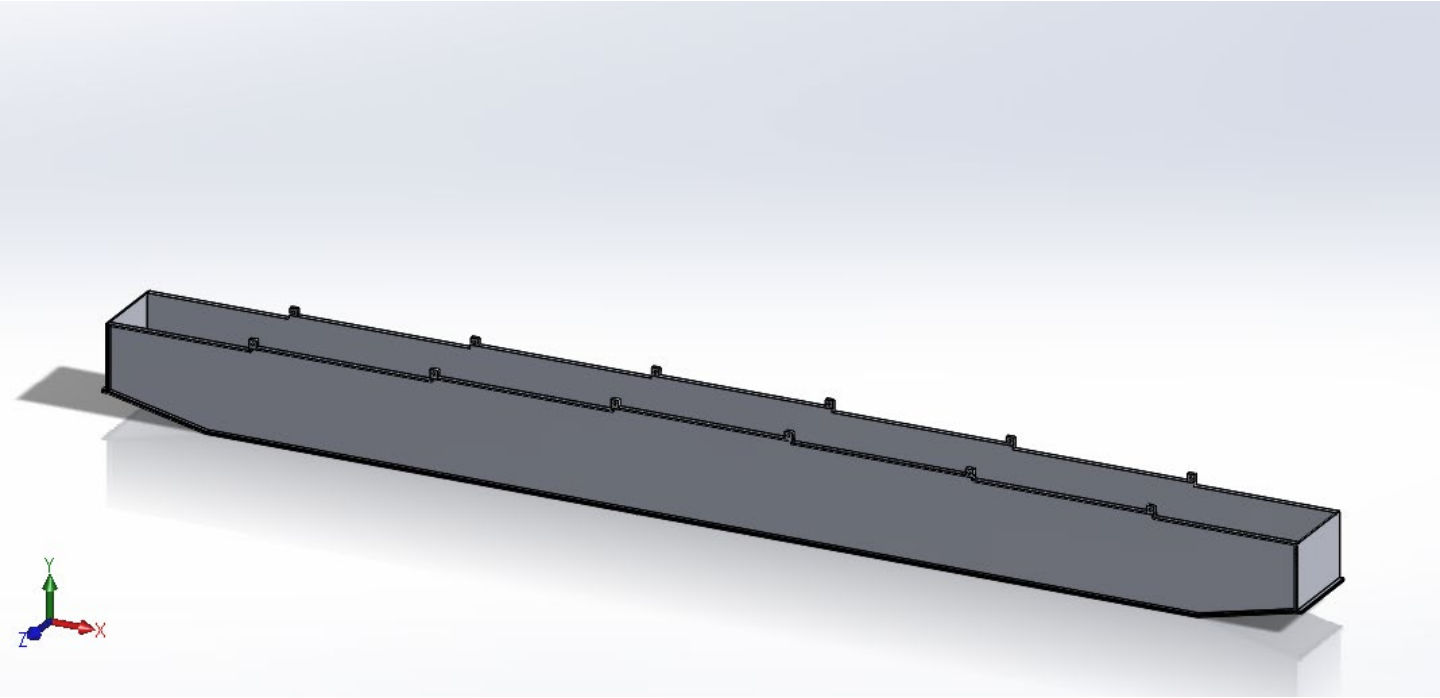

Fig: Conceptual model of an assembled five-part formwork

Participants and Collaborators:

Use the table below to list all individuals who have worked on the project.

Table 5: Active Principal Investigators, faculty, administrators, and Management Team Members			
Individual Name	**Email Address**	**Department**	**Role in Research**
Roberto Lopez-Anido	rla@mine.edu	Civil Engineering	P.I.
Douglas Gardner	douglasg@maine.edu	School of Forest Resources	Co P.I.
James Anderson	James.m.anderson@maine.edu	Advanced Structures and Composites Center	Co PI
Yousoo Han	Yousoo.han@maine.edu	Advanced Structures and Composites Center	Co PI
James Bryce	James.bryce@maine.edu	Advanced Structures and Composites Center	

Table 6: Student Participants during the reporting period				
Student Name	**Email Address**	**Class**	**Major**	**Role in research**
Sunil Bhandari		Ph.D.	Civil Engineering	Carry out analysis and design of 3D printed formwork. Evaluate different 3D printed surfaces.
Anthony Salafia		Junior	Civil Engineering	Create drawings and dimensions for 3D printed formwork.

Use the table below to list any students who worked on this project and graduated during this reporting period.

Table 7: Student Graduates			
Student Name	**Role in Research**	**Degree**	**Graduation Date**
N/Z			

Use the table below to list organizations have been involved as partners on this project and their contribution to the project.

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**
Superior Concrete	Auburn, Maine	x		x	x	

MaineDOT	Augusta, Maine				x	
PCI-NE		x			x	
ORNL	Tennessee	x			x	

List all other outputs, outcomes, and impacts here (i.e. patent applications, technologies, techniques, licenses issued, and/or website addresses used to disseminate research findings). Please be sure to provide detailed information about each item as with the tables above.

Have other collaborators or contacts been involved? If so, who and how? (This would include collaborations with others within the lead or partner universities; especially interdepartmental or interdisciplinary collaborations.

Changes:

We changed the demonstration project to bridge pier cap. Superior Concrete approached us with the idea of testing large-scale bio-based 3D printed forms for a bridge pier cap for the bridge on Ohio Street, Bangor, Maine.

Planned Activities:

We will design and 3D print a formwork for casting a pier cap. The design involves geometric design with locking and aligning mechanism, selection of suitable bio-based material, and stress analysis of the formwork to ensure stiffness and strength required for concrete casting.