

Quarterly Progress and Performance Indicators Report:

Project Number and Title: Project 2.18 - Recycling Large-scale 3D-printed polymer composite precast concrete forms

Research Area: 2 - New Materials for Longevity and Constructability

PI: Roberto Lopez-Anido, University of Maine

Co-PI(s): Sunil Bhandari, University of Maine

Reporting Period: 4/1/2022-6/30/2022

Submission Date: 6/30/2022

*****IMPORTANT:** Please fill out each section fully and reply with N/A for questions/sections with nothing to report. For ease of reporting to the USDOT, please do not remove, or change the order of, any sections/text. You may remove/add each rows in tables as needed. Thank you! ***
The report is due on the last day of the reporting period in .doc format to tidc@maine.edu.

Overview:

Provide **BRIEF** highlights of activities performed during the reporting period.

- 3D printed five sets of formworks for each of the composite materials (WF-aPLA and CF-ABS).
- Machined the formworks
- 3D printed hexagon parts for each of the composite materials (WF-aPLA and CF-ABS) for cutting coupons for testing

Meeting the Overarching Goals of the Project:

How did the previous items help you achieve the project goals and objects? Please give one bullet point for each bullet point listed above.

- Evaluate the recyclability of two different thermoplastic composite materials used in large-scale 3D printing, WF-aPLA and CF-ABS.

Accomplishments:

List any accomplishments achieved under the project goals in bullet point form...

- Designed and manufactured five sets of formworks using bio-based and conventional thermoplastic composite.

Task Progress and Budget:

Complete the following tables to document the work toward each task and budget (add rows/remove rows as needed, make sure you complete the Overall Project progress row and include all tasks even if they have ended or have not been started)...

Note: Phase 1 and Phase 2 are reported under TIDC Project 2.4

Table 1 : Phase 3 - Task Progress

Task Number	Start Date	End Date	% Complete
Task 3.1: Design and 3D printing forms	UMaine	30 Apr 2022	100
Task 3.2: Thermo-mechanical material characterization	UMaine	31 Aug 2022	5
Task 3.3: Recycling, pelletization and characterization after first use, and 3D printing forms with recycled material	UMaine/ORNL	31 Dec 2022	0
Task 3.4: Recycling, pelletization and characterization after second use, and 3D printing forms with recycled material	UMaine/ORNL	30 Apr 2023	0
Task 3.5: Recycling, pelletization and characterization after third use, and 3D printing forms with recycled material	UMaine/ORNL	31 Aug 2023	0
Task 3.6: Recycling, pelletization and characterization after fourth use, and 3D printing forms with recycled material	UMaine/ORNL	31 Dec 2023	0
Task 3.7: Recycling, pelletization and characterization after fifth use, and 3D printing forms with recycled material	UMaine/ORNL	31 May 2024	0
Task 3.8: Energy consumption and economic analysis	UMaine/ORNL	31 May 2024	0
Task 3.9: Reporting and disseminate information	UMaine/ORNL	31 Aug 2024	0

Table 2: Budget Progress

Project Budget	Spend – Project to Date	% Project to Date (include the date)
Enter Phase 1 Full Budget: \$328,615	\$26,000	8%

Is your Research Project Applied or Advanced?

- Applied** *(The systematic study to gain knowledge or understanding necessary for determining the means by which a recognized and specific need may be met.)*
- Advanced** *(An intermediate research effort between basic research and applied research. This study bridges basic (study to understand fundamental aspects of phenomena without specific applications in mind) and applied research and includes transformative change rather than incremental advances. The investigation into the use of basic research results to an area of application without a specific problem to resolve.)*

Professional Development/Training Opportunities:

Describe any opportunities for training/professional development that have been provided. Did you provide a training to a State DOT/AOT or industry organization? What was the training? When was it offered? How many people attended? Did you meet with a State DOT/AOT or industry organization to inform them of your findings and how these findings could help their organization? When? How many attended the meeting?

- N/A

Technology Transfer:

Complete all of the tables below and provide additional information where requested. Please provide ALL requested information as this is one of the most important sections for reporting to the USDOT. **ONLY provide information relevant to this reporting period.**

Use the table below to complete information about conference sessions, workshops, webinars, seminars, or other events you led/attended where you shared findings as a result of the work you conducted on this project:

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events					
Type	Title	Citation	Event	Location	Date(s)
i.e. Conference, Symposium, DOT/AOT presentation, Seminar, etc.	Presentation Title	Full Citation	Name of event (i.e. TIDC 1 st Annual Conference) or who was the presentation given to?		
Conference	Large Scale AM of Bio-Based Thermoplastic Formwork for Pre-Cast Concrete Panels	Alan LeBihan, 3D printed formworks for window openings in the precast concrete Litewall panels. Session: Industrial Application Case Studies Presentations, Day 2: Large-Area Additive Manufacturing & Business Use Cases, Manufacturing Renew3D, Orono, ME, May 23-24, 2022	Manufacturing Renew3D https://manufacturingrenew3d.com	Orono, ME	May 23-24, 2022

Use the table below to report any publications, technical reports, peer-reviewed articles, newspaper articles referencing your work, graduate papers, dissertations, etc. written as a result of the work you conducted on this project. Please list only completed items and exclude work in progress.

Table 4: Publications and Submitted Papers and Reports				
Type	Title	Citation	Date	Status
i.e. Peer-reviewed journal, conference paper, book, policy paper, magazine/newspaper article	Publication title	Full citation		i.e. Submitted, accepted, under review
N/A				

Answer the following questions (N/A if there is nothing to report):

1. Did you deploy any technology during the reporting period through pilot or demonstration studies as a result of this work? If so, what was the technology? When was it deployed?
N/A
2. Was any technology adopted by industry or transportation agencies as a result of this work? If so, what was the technology? When was it adopted? Who adopted the technology? *N/A*
N/A
3. Did findings from this research project result in changing industry or transportation agency practices, decision making, or policies? If so, what was the change? When was the change implemented? Who adopted the change?
N/A
4. Were any licenses granted to industry as a result of findings from this work? If so, when? To whom was the license granted?
N/A
5. Were any patent applications submitted as a result of findings from this research? If so, please provide a copy of the patent application with your report.
N/A
6. Were any industrial contracts awarded based on furthering planned research and development activities as a result of findings from this work? If so, when? How much was awarded? Who awarded the contract?
N/A

Please add figures/images that can be included on the website and/or in marketing/social media materials to further clarify your research to the general public.



Figure 1 – 3D printing of CF-ABS formwork



Figure 2 – CF-ABS and WF-aPLA formwork parts

Describe any additional activities involving the dissemination of research results not listed above under the following headings:

Outputs:

Definition: Any new or improved process, practice, technology, software, training aid, or other tangible product resulting from research and development activities. They are used to improve the efficiency, effectiveness, and safety of transportation systems. List any outputs accomplished during this reporting period:

- N/A

Outcomes:

Definition: The application of outputs; any changes made to the transportation system, or its regulatory, legislative, or policy framework resulting from research and development activities. List any outcomes accomplished during this reporting period:

- N/A

Impacts:

Definition: The effects of the outcomes on the transportation system such as reduced fatalities, decreased capital or operating costs, community impacts, or environmental benefits. The reported impacts from UTCs are used for the assessment of each UTC and to make a case for Federal funding of research and education by demonstrating the impacts that UTC funding has had on technology and education. NOTE: The U.S. DOT uses this information to assess how the research and education programs (a) improve the operation and safety of the transportation system; (b) increase the body of knowledge and technologies; (c) enlarge the pool of people trained to develop knowledge and utilize technologies; and (d) improves the physical, institutional, and information resources that enable people to have access to training and new technologies. List any outcomes accomplished during this reporting period:

- N/A

Participants and Collaborators:

Use the table below to list **all** individuals (compensated or not) 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@maine.edu	Civil and Environmental Engineering	PI
Sunil Bhandari	sunil.bhandari@maine.edu	Advanced Structures and Composites Center	Co-PI
James Bryce	James.bryce@maine.edu	Advanced Structures and Composites Center	Project Manager

Use the table below to list **all** students who have participated in the project during the reporting period. (This includes all paid, unpaid, intern, independent study, or any other student that participated in this project.) **ALL FIELDS ARE REQUIRED.**

Table 6: Student Participants during the reporting period								
Student Name	Start Date	End Date	Advisor	Email Address	Level	Major	Funding Source	Role in research
				Email is not included in the external report and is only used for internal purposes.	(i.e. Junior, Master's Ph.D)		(i.e. TIDC, University (non TIDC match i.e. study abroad program), unpaid intern, independent study student, etc.	What work are they conducting? Please be descriptive. Student research assistant is not enough info.
Katie Schweizer	Jun. 1, 2022	May 31, 2024	R. Lopez-Anido		Masters	CIE	TIDC	Conduct experiments, analyze data, summarize results, and write publications

Use the table below to list any students who worked on this project and graduated or received a certificate during this reporting period. Include information about the student's accepted employment (i.e. the student is now working at MaineDOT) or if they are continuing their students through an advanced degree (list the degree and where they are attending).

Table 7: Students who Graduated During the Reporting Period			
Student Name	Degree/Certificate Earned	Graduation/Certification Date	Did the student enter the transportation field or continue another degree at your university?
			Please list the organization or degree
N/A			

Use the table below to list any students that participated in Industrial Internships:

Table 8: Industrial Internships			
Student Name	Degree/Certificate Earned	Graduation/Certification Date	Did the student enter the transportation field or continue another degree at your university?
			Please list the organization or degree
N/A			

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

Table 9: Research Project Collaborators during the reporting period						
Organization	Location	Contribution to the Project				
		Financial Support	In-Kind Support	Facilities	Collaborative Research	Personnel Exchanges
		List the amount	List the amount	Mark with an "x" where appropriate		
Sustainable Manufacturing Technologies Group, Manufacturing Sciences Division, Oak Ridge National Laboratory (ORNL)	Knoxville, TN		\$ 268,360	X	X	X
Unistress Corporation	Pittsfield, MA				X	

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

(List your technical champion(s) in this table. This also includes collaborations within the lead or partner universities who are not already listed as PIs; especially interdepartmental or interdisciplinary collaborations.)

Table 10: Other Collaborators				
Collaborator Name and Title	Contact Information	Organization and Department	Date(s) Involved	Contribution to Research
	For internal use only			(i.e. technical champion, technical advisory board, test samples, on-site equipment, data, etc.)
Rita L. Seraderian, P.E., FPCI, Executive Director		PCI-NE	2019-02-01 present	Technical champion

Use the following table to list any transportation related course that were taught or led by researchers associated with this research project:

Table 11: Course List						
Course Code	Course Title	Level	University	Professor	Semester	# of Students
i.e. CE 123		Grad or undergrad?	Where was the course taught?	Who taught the course?	Enter Spring, Fall, Summer, Winter and the year	How many students were enrolled in the class?
CIE 545	Structural Dynamics	Grad	Orono, ME	Dr. Bhandari	Spring 2022	5

Changes:

List any actual or anticipated problems or delays and actions or plans to resolve them (list no-cost extension requests here)...

The schedule has been affected by disruption of day-to-day laboratory and office work due to the University shutdown in response to COVID-19 health safety precautions.

List any changes in approach and the reasons for the change...

Planned Activities:

List the activities planned during the next quarter.

- Cast concrete parts using 3D printed formwork.
- Remove/strip the forms and prepare them for recycling
- Conduct thermo-mechanical characterization tests
- Investigate the effectiveness of removing debris and contaminants from the formwork with pressure washers.