Quarterly Progress Report:
Project Number and Title: 2.3: Measuring Adhesion Between Binders and Aggregates Using Particle Probe Scanning Force Microscopy at Low Temperatures
Research Area: Thrust 3 Use New Materials and Systems to Build Longer-lasting Bridges and Accelerate Construction
PI: *Ting Tan, University of Vermont*
Co-PI(s): *Co-PIs and home institution(s)*
Reporting Period: *10.01.2019 to 12.31.2019*
Date: *Date*

Overview: (Please answer each question individually)

Overview and summary of activities performed during previous six months

The funded start date of this project is 10.01.2019. The primary activities have been:

1. Fill out the project research team – PI Ting Tan has been working with a graduate student Zhuang Liu for the interfacial avalanche study between the steel fiber and cement matrices. PI Tan has been working on the adhesion modeling between aggregates and asphalt binders.

2. For the experimental part, PI Tan and Zhuang Liu has performed four-point bending experiments for steel fiber reinforced concrete beams with 0.5 and 1% fiber volume fractions at different loading rates (0.03 and 0.15 in/min). Avalanches occurred at the post-peak tails have been collected and analyzed for their statistics and dynamics.

3. Literature review has been performed to study the mesoscale modeling between the aggregate minerals and asphalt binders. Benchmark molecular model are being tested for the molecular representation of calcium carbonate, including data file preparation and simple model validation.

Context as to how these activities are helping achieve the overarching goal of the project

The research objectives of this project are to understand the interfacial behavior between reinforcements and matrices, such as adhesion between asphalt binders and aggregate minerals, or steel fibers and cement matrices, including

1. Experimental study on avalanche between steel fibers and cement matrices

2. Experimental and mathematical study of adhesion between asphalt binders and aggregate minerals to understand the effects of chemical components on the interfacial adhesion.

Accomplishments achieved under the project goals

The accomplishments are primarily the results reported above, i.e., experimental study on avalanches between steel fibers and cement matrices, literature review of the mesoscale adhesion modeling, and the benchmark modeling of the adhesion between asphalt binders and aggregate minerals.

Complete the following tables to document the work toward each task and budget

Table 1: Task Progress

Task Number	Start Date	End Date	% Complete
Task 1: Steel/cement interfacial avalanche	8/01/2019	12/31/2019	30
Task 2: Aggregate-binder adhesion modeling	9/01/2019	12/31/2019	15
Overall Project:	Initial Start Date	Planned End Date	

Table 2: Budget Progress		
Project Budget	**Spend – Project to Date**	**% Project to Date**
N.A.	N.A.	N.A.

Opportunities for training/professional development that have been provided

UVM engineering graduate Zhuang Liu participated in the avalanche study during the fall 2019.

Activities involving the dissemination of research results

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events				
Title	**Event**	**Type**	**Location**	**Date(s)**
Presentation title	Name of event (i.e. TIDC 1st Annual Conference)	i.e. Conference, Symposium, Seminar,		
N.A.	N.A.	N.A.	N.A.	N.A.

Table 4: Publications and Submitted Papers and Reports				
Type	**Title**	**Citation**	**Date**	**Status**
i.e. Peer-reviewed journal, conference paper, book, policy paper	Publication title	Full citation		I.e. Submitted, accepted, under review
Peer-reviewed journal	Avalanches during flexure of early-age steel fiber reinforced concrete beams	N.A.	Dec, 2019	Submitted

Figures

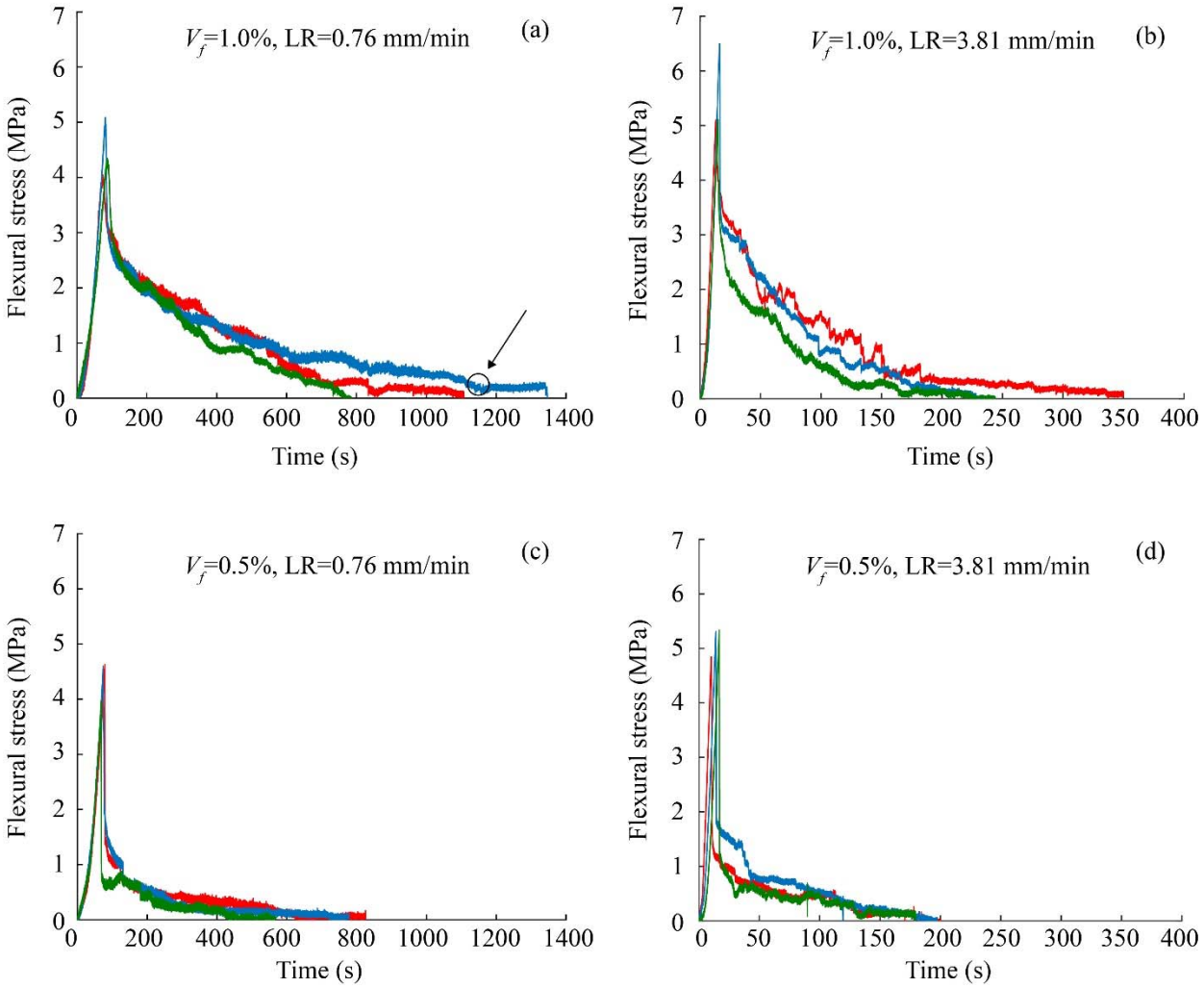

Fig. 1. Stress-time curves at 100 kHz of different steel-fiber beams during flexure (a) 1.0% fiber volume fraction, 0.76 mm/min loading rate; (b) 1.0% fiber volume fraction, 3.81 mm/min loading rate; (c) 0.5% fiber volume fraction, 0.76 mm/min loading rate; (d) 0.5% fiber volume fraction, 3.81 mm/min loading rate. Red, green and blue curves represented the three replicas in each group.

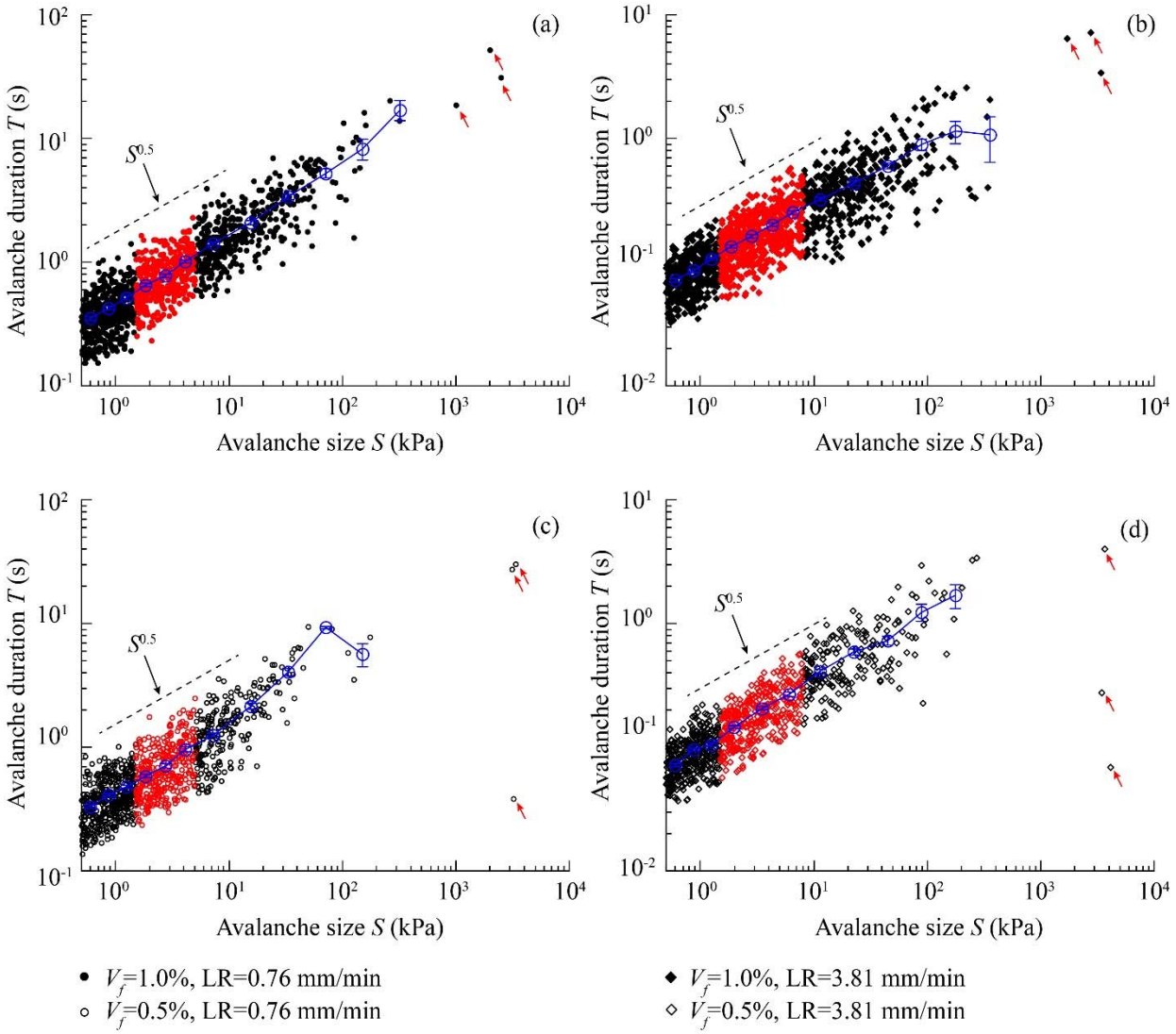

Fig. 2. Avalanche durations versus sizes for different groups (a) 1.0% fiber volume, 0.76 mm/min loading rate; (b) 1.0% fiber volume, 3.81 mm/min loading rate; (c) 0.5% fiber volume, 0.76 mm/min loading rate; (d) 0.5% fiber volume, 3.81 mm/min loading rate. Scaling regimes were highlighted in red.

Participants and Collaborators:

Table 5: Active Principal Investigators, faculty, administrators, and Management Team Members			
Individual Name	**Email Address**	**Department**	**Role in Research**
	Email is not included in the external report and is only used for internal purposes.		
Ting Tan	Ting.Tan@uvm.edu	Civil and Environmental Engineering	PI

Dryver Huston	Dryver.Huston@uvm.edu	Mechanical Engineering	Co-PI

Use the table below to list all students who have participated in the project.

Table 6: Student Participants during the reporting period				
Student Name	**Email Address**	**Class**	**Major**	**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)		
Zhuang Liu		Ph.D	Civil Engineering	Perform experiments on avalanche study

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.A.	N.A.	N.A.	N.A.

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**
N.A.	N.A.	Mark the appropriate contribution with an "x"	N.A.	N.A.	N.A.	N.A.

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Changes:

Actual or anticipated problems or delays and actions or plans to resolve them

Because the scanning force microscope is broken, we are working dedicatedly to fix it. PI Tan propose to apply for a no cost extension of the particle probe project for 6 months. Thank you for your consideration. All help is greatly appreciated.

Changes in approach and the reasons for the change: NA

Planned Activities:

Planning for the research – Experimentally, we will fabricate assemble the microprobe to the scanning force microscopy. For modeling, we will complete the bench mark test for the calcium carbonate and test different potentials of adhesion studies based on representative asphalt binders.