Quarterly Progress Report:
Project Number and Title: 3.12—Lateral Loading of Unreinforced Rigid Elements and Basal Stability of Columns Supported Systems
Research Area: Geotechnical Infrastructure Engineering
PI: *Aaron Gallant, University of Maine*
Co-PI(s):
Reporting Period: *01/2019-03/2019*
Submission Date: *3/27/2020*

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 **no more than 3 bullet points no more than 1 sentence each** ….*

The activities carried out during this reporting period were:

- Calibration a field case corresponding to the Council Bluffs Interchange System (CBIS), specifically focusing on lateral deformations monitored next to tall MSE walls (Figure 1).
- A parametric study to assess basal stability beneath GRCS embankments (Table 1) is currently underway.

Provide context as to how these activities are helping achieve the overarching goal(s) of the project…

Field Case:

A section through the inclinometer 7HS presented in Figure 1 was analyzed in Plaxis 3D. The soil parameters were calibrated with laboratory soil testing and field performance data. We note that good agreement show in Figure 1b is not the product of inverse analysis of the soil constitutive parameters, and soil parameters were diligently calibrated with laboratory data. Discrete cracks were introduced via an interface through columns to asses the loss of bending resistance and to study its effects on performance and basal stability. For this case, column fracturing imitates in the perimeter columns at a 6 m fill height. Subsequent cracking initiates in other columns as filling progresses. Though the columns crack and lose bending capacity, there is not a cessation of the column-supported system (i.e. does not stop transferring load vertically) and it performed well. Thus, illustrating that column yielding of the column in bending alone should not dictate basal stability of the system.

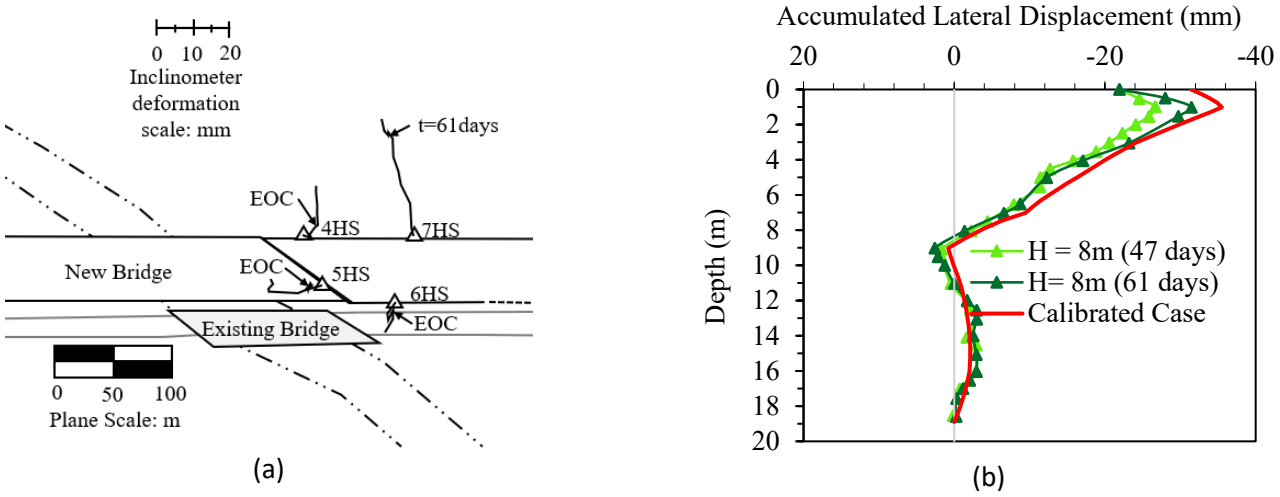
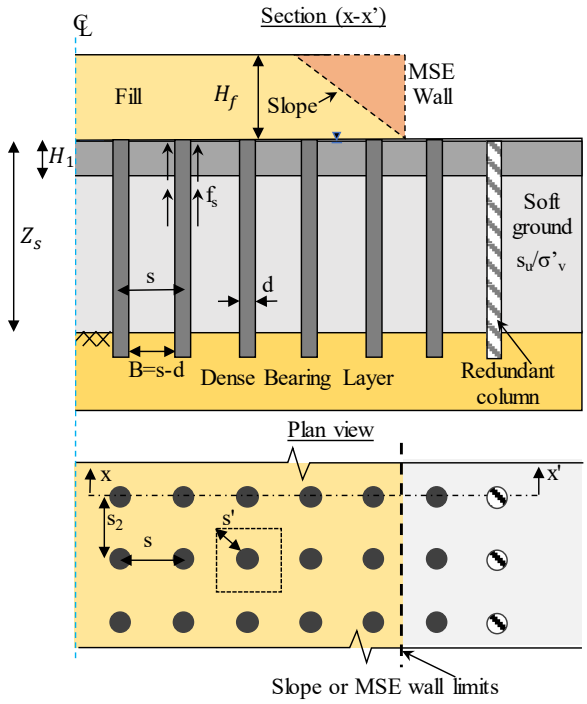


Figure 1. Lateral deformation in the CBIS field case: (a) plan view of inclinometer and its lateral deformation; (b) comparison of calibrated FEA model with measured displacements at location 7.

Parametric Study:

The parametric study is initially focused on assessing clay depth, shear strength, and presence of a stiff surficial crust on basal stability after a fracture develops due to bending. All models are analyzed for the undrained condition in soft soil (i.e. no dissipation of excess pore water pressures), as this case represents rapid embankment construction, which column-supported systems are meant to facilitate. Figure 2 presents the initial parameters being studied for each case.



		CSE Geometry				Subsoil parameters				
	CSE ID	d_c	s	s'/d_c	H:V	Z_s	s_u	$E^{ref}_{50}=E^{ref}_{oed}$	E^{ref}_{ur}	H_1
		(m)	(m)			(m)		(MPa)	(MPa)	(m)
1	CS1	0.5	2	2.3	2:1	5	$0.27\sigma'_v+5$	1.3	19	0.0
2	CS2					5	$0.27\sigma'_v+5$			1.5
3	CS3					5	$0.27\sigma'_v+10$			0.0
4	CS4					5	$0.27\sigma'_v+10$			1.5
5	CS5					5	$0.27\sigma'_v+15$			0.0
6	CS6					5	$0.27\sigma'_v+15$			1.5
7	CS7					10	$0.27\sigma'_v+5$			0.0
8	CS8					10	$0.27\sigma'_v+5$			1.5
9	CS9					10	$0.27\sigma'_v+10$			0.0
10	CS10					10	$0.27\sigma'_v+10$			1.5
11	CS11					10	$0.27\sigma'_v+15$			0.0
12	CS12					10	$0.27\sigma'_v+15$			1.5
13	CS13					15	$0.27\sigma'_v+5$			0.0
14	CS14					15	$0.27\sigma'_v+5$			1.5
15	CS15					15	$0.27\sigma'_v+10$			0.0
16	CS16					15	$0.27\sigma'_v+10$			1.5
17	CS17					15	$0.27\sigma'_v+15$			0.0
18	CS18					15	$0.27\sigma'_v+15$			1.5

Note: In all cases the columns properties were: f'_c=25 MPa, f_t=2.8 MPa, E_c= 25 GPa, and L_{emb}= 2m.

Figure 2. Layout of parametric study

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, make sure you complete the Overall Project progress row and include all tasks even if they have ended or have not been started)…

Table 1: Task Progress			
Task Number	**Start Date**	**End Date**	**% Complete**
Task 1: Assess stresses in subsoil.	06/2018	06/2019	100%
Task 2: Establish a numerical approach to account for fracture in basal stability.	06/2019	09/2019	100%
Task 3: Calibrate models with field measurements that include lateral and vertical deformations.	06/2019	01/2020	95%

Task 4: Perform parametric study.	01/2020	04/2020	20%
Task 5: Recommended design guidance for industry.	03/2020	05/2020	5%
Overall Project:	06/2018	05/2020	64%

Table 2: Budget Progress		
Project Budget	**Spend – Project to Date**	**% Project to Date***
$33,380	$24,916	74.6% (3/31/2020)

Include the date the budget is current to.

Describe any opportunities for training/professional development that have been provided…

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**
Journal	Field Observations and Analysis of the Subgrade Response beneath GRCS Embankments at the Council Bluffs Interchange System	Gallant, Aaron, Ehab Shatnawi, and Danilo Botero-Lopez. 2019. "Field Observations and Analysis of the Subgrade Response beneath GRCS Embankments at the Council Bluffs Interchange System." Journal of Geotechnical and Geoenviromental Engineering (in press).	2020	Accepted

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**
Aaron Gallant	aaron.gallant@maine.edu	Civil	PI

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

Table 6: Student Participants during the reporting period				
Student Name	**Email Address**	**Class**	**Major**	**Role in research**
Danilo Botero-Lopez		Master	Master of Civil Engineering	

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			

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**
Deep Foundations Institute (DFI)	Hawthorne, NJ	x				
Jacobs Engineering	Herndon, VA		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.)

Table 9: Other Collaborators			
Collaborator Name and Title	**Contact Information**	**Organization and Department**	**Contribution to Research**
N/A			

Who is the Technical Champion for this project?
Name: Tanner Blackburn
Title: Chief Geotechnical Engineering
Organization: Hayward Baker
Location (City & State):
Email Address:

Changes:
N/A

Planned Activities:

Future work will be focused on the parametric study for Column supported embankments to facilitate creation of design guidelines regarding lateral loading and basal stability of these systems.