Semi-Annual Progress Report:

Project Number and Title: 3.7 Development of general guidelines on the effects of bridge span range and skew angle range on integral abutment bridges (IAB's)

Research Area: Trust 3: New systems for longevity and constructability
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Reporting Period: 8/1/2019-9/30/2019
Date: 9/30/2019

Overview:
The overall objective of this research is to improve guidelines for the modeling, design, and construction of IABs for the following:

(a) The effect of the roadway profile grade on substructure;

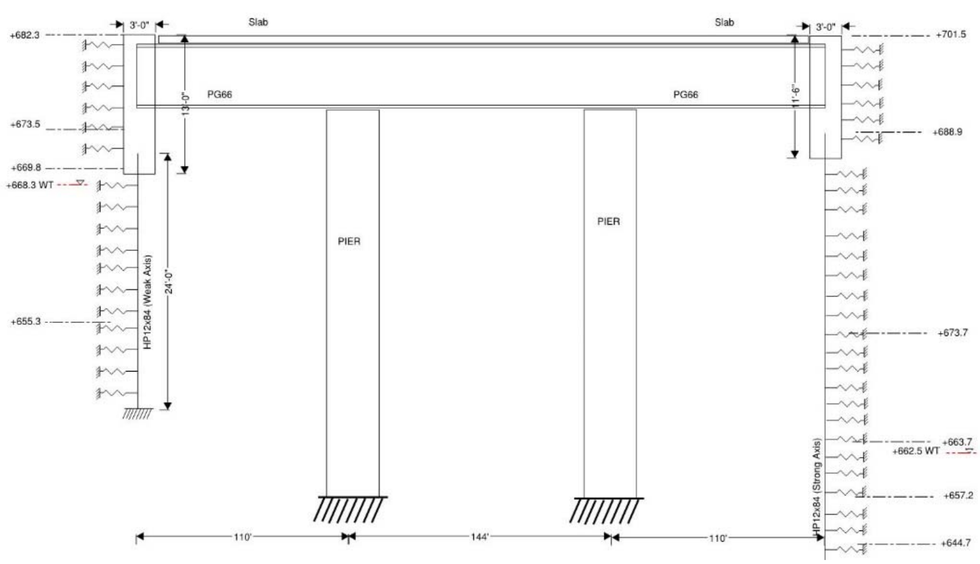
(b) The constructability of pile supported IABs at a site with shallow bedrock;

(c) The effect of range span and of skew angle on axial and bending stresses in the superstructure and substructure;

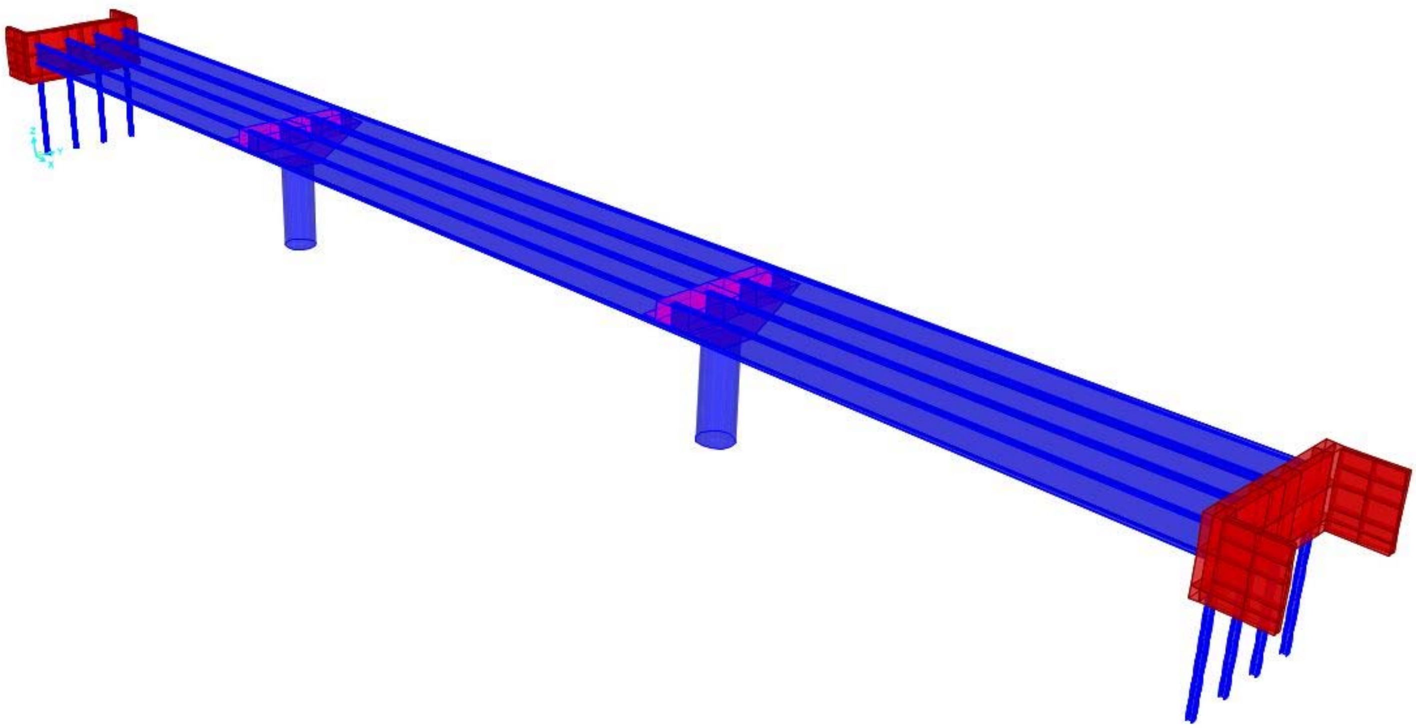
(d) Improvement of the finite–element modeling and analysis of IABs.

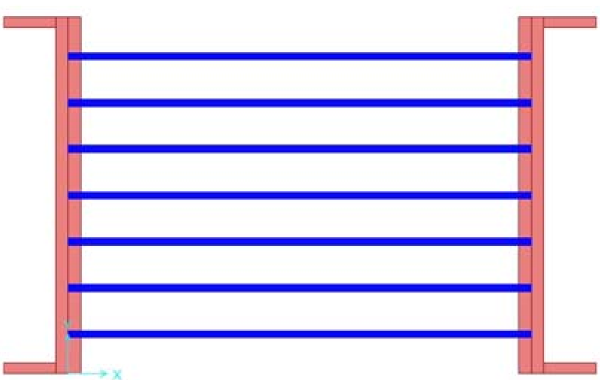
Summary of the activities performed during the reporting period:

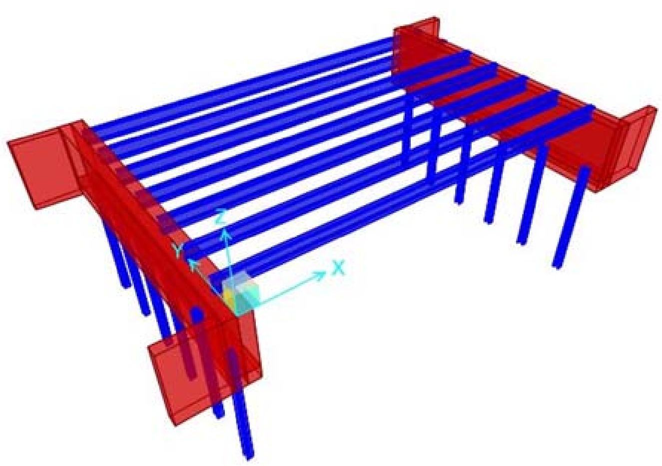
- A full three dimensional finite element model of a single span, non-skew sample IAB was completed.
- A full three dimensional finite element model of a single span skew sample IAB was completed.
- Two dimensional finite element models of three sample IABs incorporating the nonlinear soil response behind the abutment walls and adjacent to the HP piles were completed.



- Wing walls were added to the three dimensional finite element models of three sample IABs in order to study the effect of wing wall stiffness on the twisting of the piles and on the redistribution of soil pressure acting on the abutment walls for skewed IABs under thermal loading.

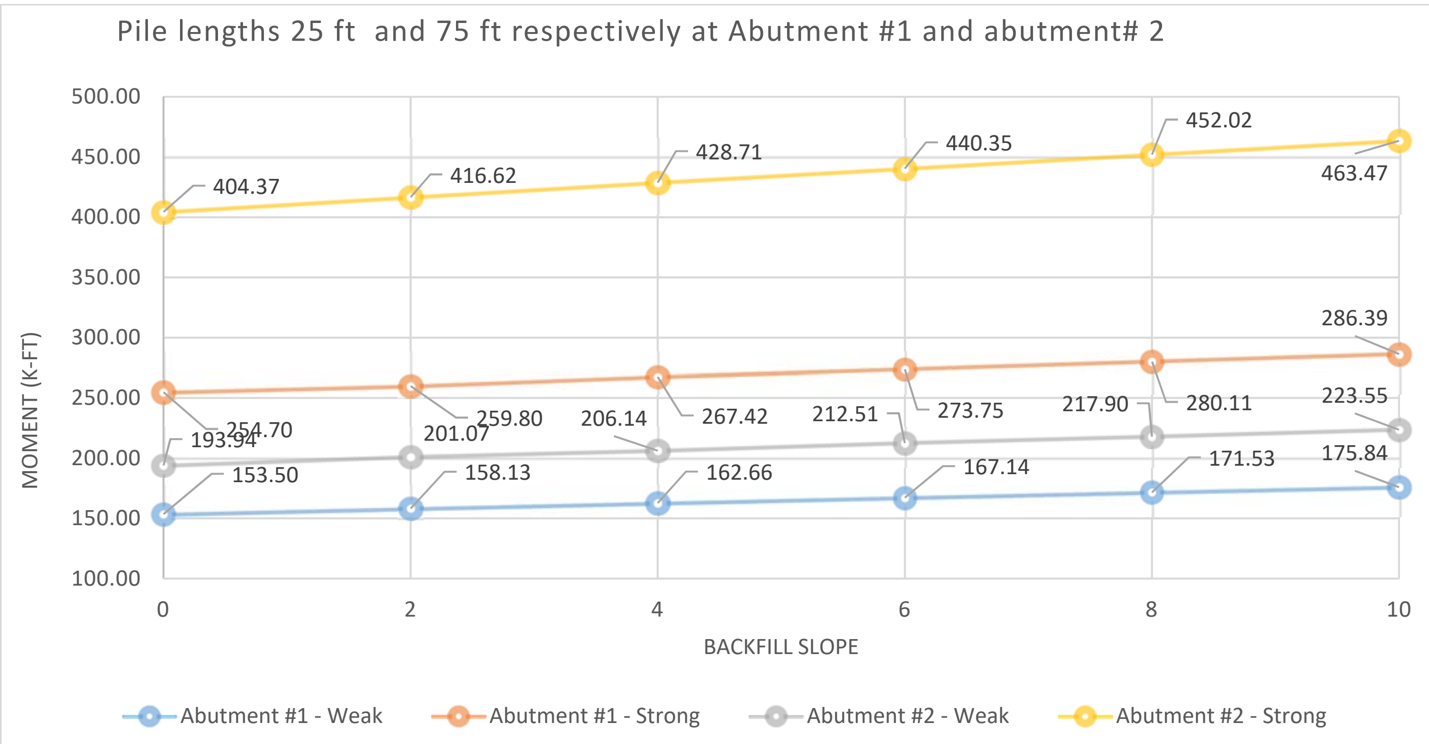




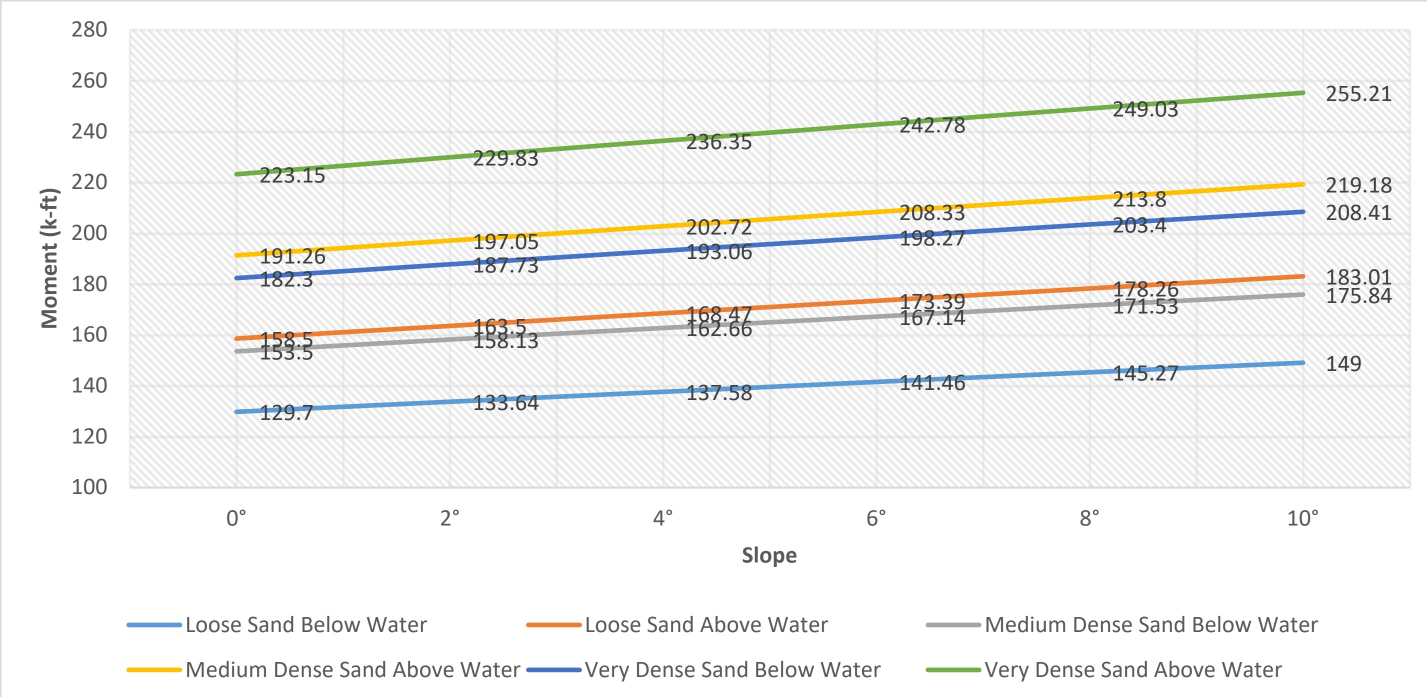


- Parametric studies were conducted on three sample bridges by varying sets of parameters, such as the roadway profile grade, the soil compaction level next to the HP piles, the orientation of the HP piles, and the length of the HP piles, while keeping the stiffness of the superstructures constant, in order to study the impact on the distribution of forces between superstructure and substructure.

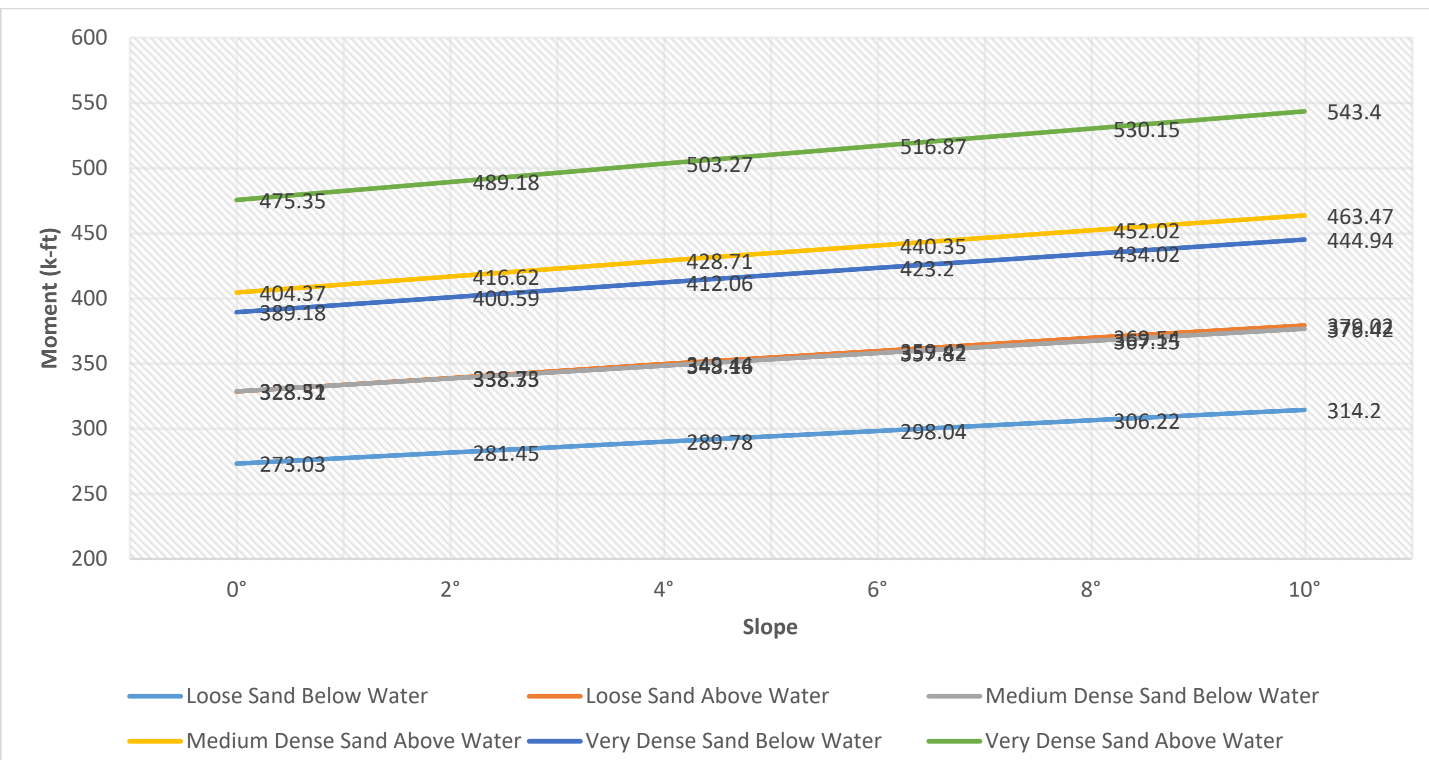
Some of the results are shown in the following tables and figures:



Pile head moments (kip ft) for HP12x84 piles vs range of slope under thermal loading for a three span sample bridge



Plot of maximum moments (kip ft) for HP12x84 piles (L=25ft, week axis) vs range of slope under thermal loading for a three span sample bridge



Plot of maximum moments (kip ft) for HP12x84 piles (L=75ft, strong axis) vs range of slope under thermal loading for a three span sample bridge

Maximum moments (kip ft) for HP12x84 piles (L=25 ft, weak axis) caused by thermal loading for three span sample bridge

Soil Type	Roadway Slope						Fixity Length (ft)
	0°	2°	4°	6°	8°	10°	
	M_{max}	M_{max}	M_{max}	M_{max}	M_{max}	M_{max}	
Loose Sand Below Water	129.7	133.64	137.58	141.46	145.27	149	22.5
Loose Sand Above Water	158.5	163.5	168.47	173.39	178.26	183.01	19.6
Medium Dense Sand Below Water	153.5	158.13	162.66	167.14	171.53	175.84	17.4
Medium Dense Sand Above Water	191.26	197.05	202.72	208.33	213.8	219.18	15.6
Very Dense Sand Below Water	182.3	187.73	193.06	198.27	203.4	208.41	14.7
Very Dense Sand Above Water	223.15	229.83	236.35	242.78	249.03	255.21	13.1

Maximum moments (kip ft) for HP12x84 piles (L=75ft, strong axis) caused by thermal loading for three span sample bridge

Soil Type	Roadway Slope						Fixity Length (ft)
	0°	2°	4°	6°	8°	10°	
	M_{max}	M_{max}	M_{max}	M_{max}	M_{max}	M_{max}	
Loose Sand Below Water	273.03	281.45	289.78	298.04	306.22	314.2	25.7
Loose Sand Above Water	328.32	338.73	349.44	359.42	369.54	379.02	24.2
Medium Dense Sand Below Water	328.51	338.35	348.16	357.82	367.15	376.42	21.9
Medium Dense Sand Above Water	404.37	416.62	428.71	440.35	452.02	463.47	19.6
Very Dense Sand Below Water	389.18	400.59	412.06	423.2	434.02	444.94	18.8
Very Dense Sand Above Water	475.35	489.18	503.27	516.87	530.15	543.4	16.5

All the research done to date falls within the parameters of the three tasks listed

Participant and Collaborators:

During the reporting period, the following participants have worked on the project:

. Dr. Susan Faraji, Professor, Civil and Environmental Engineering, UML – Project principal investigator

. Mr. Hamed Abshari, graduate RA, Doctoral candidate, Civil and Environmental Engineering, UML-computer modeling and data analysis (started May 2019)

. Sina Razzaghi, undergraduate RA, Masters Candidate, Civil and Environmental Engineering, UML-Computer modeling (Summer 2019)

Collaborators during the reporting period:

. Vermont Agency of Transportation.

. The other collaborators and contacts that have been involved in the project include Intergraph Corporation of Madison, Alabama, and ADAPT Corporation of Redwood City, California.

Changes:

No problems or changes are anticipated at this stage of the project.

Planned Activities:

- A full three dimensional finite element model of additional sample bridges will be completed to be used for the parametric study.
- Two-dimensional finite element models of additional sample bridges incorporating the nonlinear soil response behind the abutment walls and adjacent to the HP piles will be completed to be used for the parametric studies.
- Parametric studies will be continued using all sample bridges by varying sets of parameters, such as the roadway profile grade, the soil compaction level next to the HP piles, the orientation of the HP piles, the length of the HP piles, and wing wall stiffness, while keeping the stiffness of the superstructure constant, in order to study the impact on the distribution of forces between superstructure and substructure.