Quarterly Progress Report:

Project Number and Title: 3.7 Development of general guidelines related to the effects of factors such as the bridge span range, range of pile length, roadway profile grade, and skew angle range on integral abutment bridges (IABs)

Research Area: Trust 3: New systems for longevity and constructability

PI: Susan Faraji, University of Massachusetts Lowell

Reporting Period: 7/1/2021 - 9/30/2021

Submission Date: 9/28/2021

Overview:

The overall objective of this research is to improve the guidelines for the modeling, design, and construction of integral abutment bridges (IABs). Based on input from the DOTs the following topics were considered for the study: (1) a study of the effect of skew angle and other factors on the distribution of forces between superstructure and substructure; (2) a study of the effect of the roadway profile grade on the substructure; and (3) a study of the constructability of HP piles supported on a site with shallow bedrock.

Year 3

The focus of the third year of this ongoing research has been:

(a) To verify the findings of the analytical study in Years 1 and 2 of skew IABs. This is being done by means of a parametric study using a full three dimensional finite element model of a sample single span skew IAB, varying parameters such as the skew angle, the ratio of the length to the width of the bridge, and the stiffness parameters of substructure;

(b) To provide enhanced guidelines for the finite-element modeling and the assessment of the impact of modeling techniques on the accuracy of the analysis results for skew and non-skew IABs. Input from the DOTs and from industry will be taken into consideration in the developing of these guidelines.

Summary of the activities performed during the reporting period:

- Four three dimensional finite element models of a single span IABs were created. All four models had an identical superstructure and substructure properties, except for the different skew angles, of 0, 10, 20, and 30 degrees, respectively, at the abutments.

Then parametric studies were conducted for these four sample IABs for a length to width ratio (a/b) of 1.4, and the relative stiffness parameter ($\beta = 0$). The normal horizontal displacements behind the abutment walls near the deck level were plotted and compared with previously conducted analytical study results (See Figures 1, 2 and 3). The parametric study results of all four sample IABs with a/b of 1.4 and of $\beta = 0$ were in agreement with the previously conducted analytical study in Years 1 and 2. These results were presented at the VTrans Research and Innovation Symposium in September 2021.

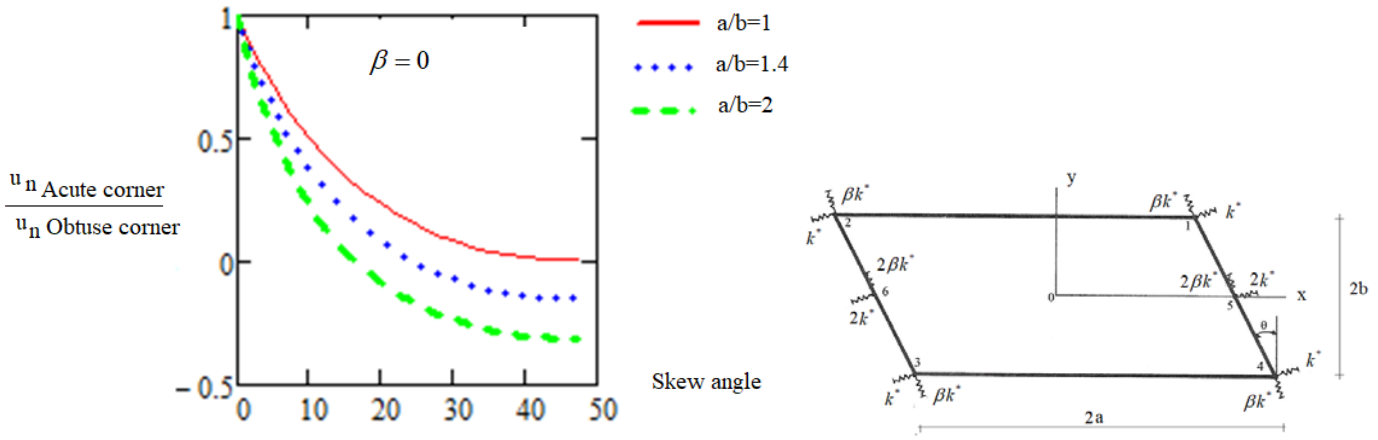


Fig. 1 Variation of the ratio of normal displacements at the corners of the plate for a range of skew angles under thermal expansion for ranges of a/b=1, 1.4, 2 and $\beta = 0$ (the results of the analytical study)

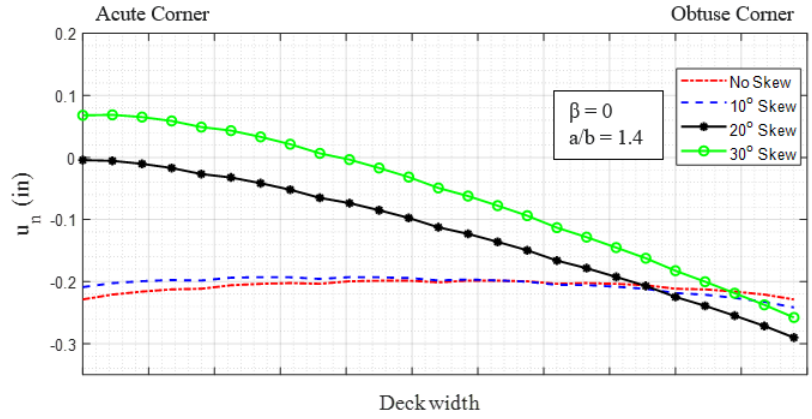
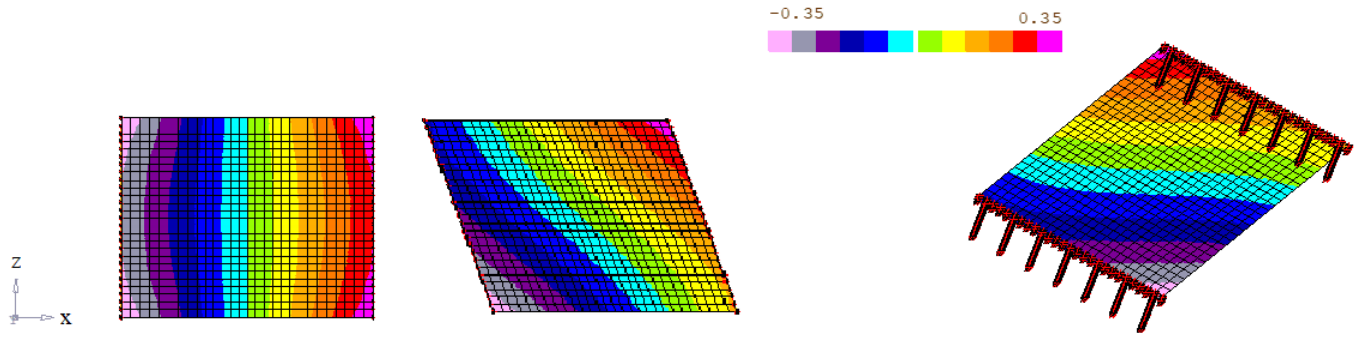


Fig. 2 Normal horizontal displacement behind the abutment wall near the deck level for a single span sample IAB for a range of skew angles under thermal expansion for a/b=1.4 and $\beta = 0$ (the results of the parametric study)



(a) Non-skew (b) 20^0 skew (c)Isometric view, 20^0 skew

Fig. 3 Displacement contours for a sample single span IAB under thermal expansion for a/b=1.4 and $\beta = 0$

- Continued discussions of the findings of the ongoing research project with the Champion of the project through Zoom meetings, phone discussions, and email exchanges.

- The teaching of a new graduate level bridge design course, CIVE.5580, at UMass Lowell with 35 graduate students started September 1, 2021. The course uses AASHTO, LRFD Bridge Design Specifications, 9th edition, covering the analysis and design of integral abutment bridges (IABs) and including some of my research findings in the course.

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

Table 1: Task Progress Year 3

Task Number	Start Date	End Date	% Complete
Overall Project:	1/1/2021	12/31/2021	60%

Table 2: Budget Progress Year 3

Project Budget	Spend – Project to Date	% Project to Date*
$125,625 (62,500 + 63,125)	**0**	20 %

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events

Title	Event	Type	Location	Date(s)
Parameters effecting the in-plane rotation of skewed integral abutment bridges(IABs) under thermal expansion	VTrans Research and Innovation Symposium	Presentations	Virtual	September 8, 2021 September 9, 2021
Attendee	TIDC Annual Conference	Sessions	Virtual	July 27, 2021 July 28, 2021
Discussion of Design and modeling of IAB's	Presentations to Project Champion at Vermont Agency of Transportation	Sessions	Virtual	July 7, 2021 August 27, 2021

Table 5: Active Principal Investigators, faculty, administrators, and Management Team Members			
Individual Name	**Email Address**	**Department**	**Role in Research**
Dr. Susan Faraji, Professor	Susan_Faraji@uml.edu	Civil and Environmental Engineering	Project Principal Investigator

Table 6: Student Participants during the reporting period			
Email Address	**Class**	**Major**	**Role in research**
Harsh Gandhi	Ph.D.	Civil and Environmental Engineering	Use of LPILE software for soil modeling and data analysis

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**
Vermont Agency of Transportation	Vermont		x (Bridge design)		x	x (Technical Champion)
ENSOFT Inc.	Texas		x (computer software)			x (Technical support)
Hexagon PPM/Intergraph Corporation	Alabama		x (Computer software)			x (Technical support)

Technical Champion for this project:

Mr. James Lacroix PE

State Bridge Design Engineer

Vermont Agency of Transportation

James.Lacroix@vermont.gov

Tel: 802-272-6862

Changes:

No change

Planned Activities:

- Continue with the parametric study and data analysis of the four sample bridges varying the length to width ratio (a/b) and the relative stiffness parameter (β).

- Extend the parametric study and data analysis to sample IABs where the stiffnesses of the HP piles and the soil surrounding them vary from one abutment to the other.

- Continue with the documentations and presentations of the outcomes of the ongoing research.