TIDC Transportation Infrastructure Durability Center AT THE UNIVERSITY OF MAINE

Quarterly 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 (IABs)

Research Area: Trust 3: New systems for longevity and constructability
PI: Susan Faraji, University of Massachusetts Lowell

Reporting Period: 10/1/2019-12/31/2019
Submission Date: 12/29/2019

Overview:

The overall objective of this research is to improve the guidelines for the modeling, design, and construction of integral abutment bridges (IABs) in relation to the following:

Task 1: The effect of the roadway profile grade on substructure;

Task 2: The constructability of pile supported IABs at a site with shallow bedrock;

Task 3: The effect of range span and of skew angle on axial and bending stresses in the superstructure and Substructure;

Task 4: Recommendations for improvement of the finite–element modeling and analysis of IABs;

Summary of the activities performed during the reporting period:

- The finite element models of all five sample bridges provided by VTrans are completed.

- Mr. Alexander Bardow, State Bridge Engineer for the Massachusetts, agreed to provide two additional integral abutment bridges in Massachusetts within the next month for parametric studies. One bridge has piles of different lengths (Bridge Number P-10-049). At the present time, this bridge is in the contract award phase. The second bridge is a 96 ft. single span bridge with a skew of 42 degrees and a superstructure composed of spread prestressed concrete box beams (Bridge Number B-28-006).

- Study of behavior of skew integral abutment bridges
  When integral abutments are skewed the behavior is more complicated. Non-skew bridges experience uniformity when the temperature is increased and the lateral soil pressure behind the abutment wall near the deck level tends toward the passive pressure limit state. Skewed integral abutment bridges experience a rotation in the horizontal plane under thermal loading, which causes a redistribution of soil pressure acting on the abutment walls and so a non-uniform soil pressure behind the wall. Rotation tends to decrease translation at the acute corner and increase translation in the obtuse corner. Therefore, the deformation pattern for skew bridge may differ substantially from the non-skew state and produce unanticipated local cracking.
  The specific objective of this study is to determine the effect of skew angle on the pack fill pressure and to determine how this effect relates to the deck movements arising from thermal changes. To accomplish this objective, the superstructure was treated as a rigid skewed plate supported by springs on the plate boundaries. A closed form analytical solution was generated that will be used to verify results from finite elements modeling of sample bridges.

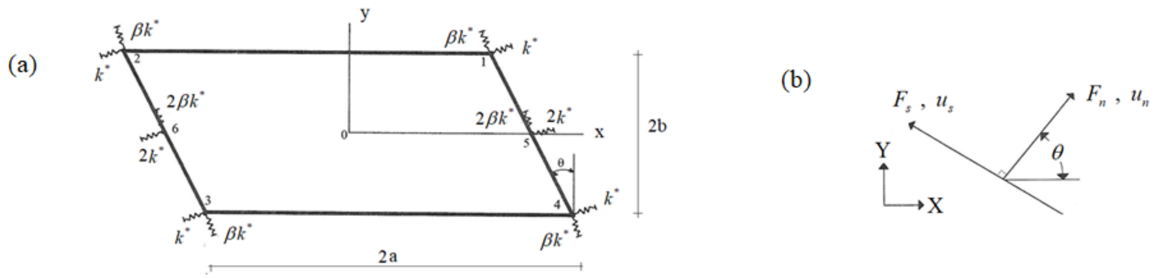

Fig.1 (a) Geometry of a skew plate and location of springs, (b) Orientation of normal and tangential axes

The analytical solution indicates that the rigid plate experiences a rotation in the horizontal plane under the thermal loading. The rotation depends on the relative stiffness parameter β (the ratio of stiffness of the abutment and surrounding soil tangent to the skew to the stiffness of the abutment and surrounding soil normal to the skew), the skew angle θ , the length to width ratio of the plate a/b ,where β is the major contributor.

Rotation tends to produce twisting in the piles and redistribution of soil pressure acting on the abutment walls which might produce unanticipated local cracking. By increasing β (the ratio of stiffness of the abutment and surrounding soil tangent to the skew to the stiffness of the abutment and surrounding soil normal to the skew), the rotation of the bridge in the horizontal plane will decrease dramatically.

Some of the analytical solutions results are shown in the following figures:

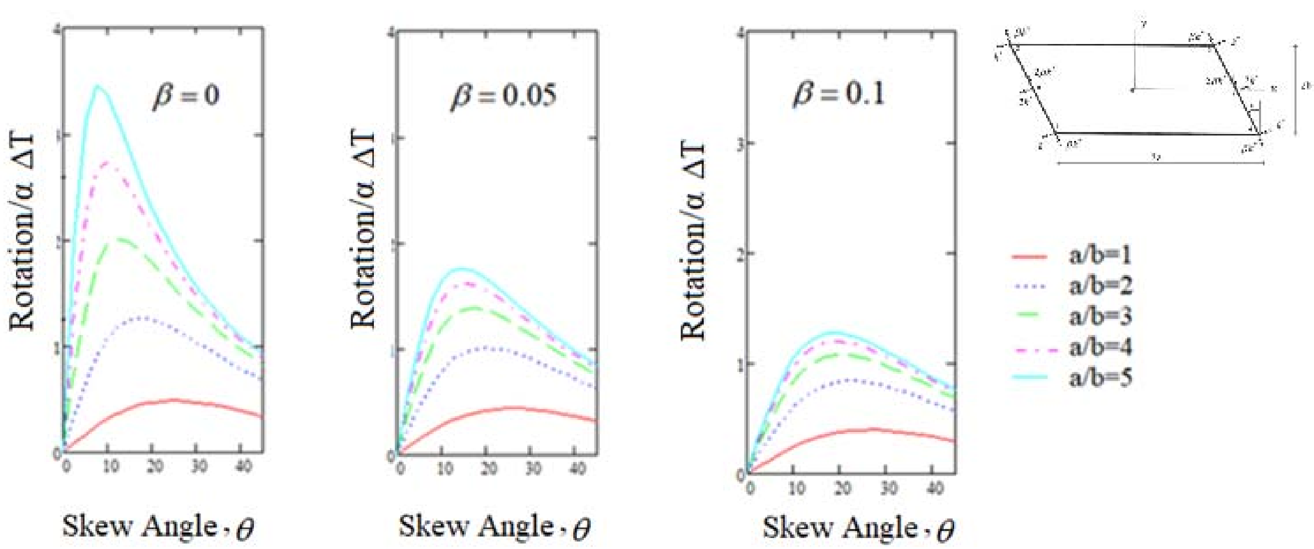

Fig.2 Variation of in-plane rotation of a skewed rigid plate with θ for a representative range of a/b and β

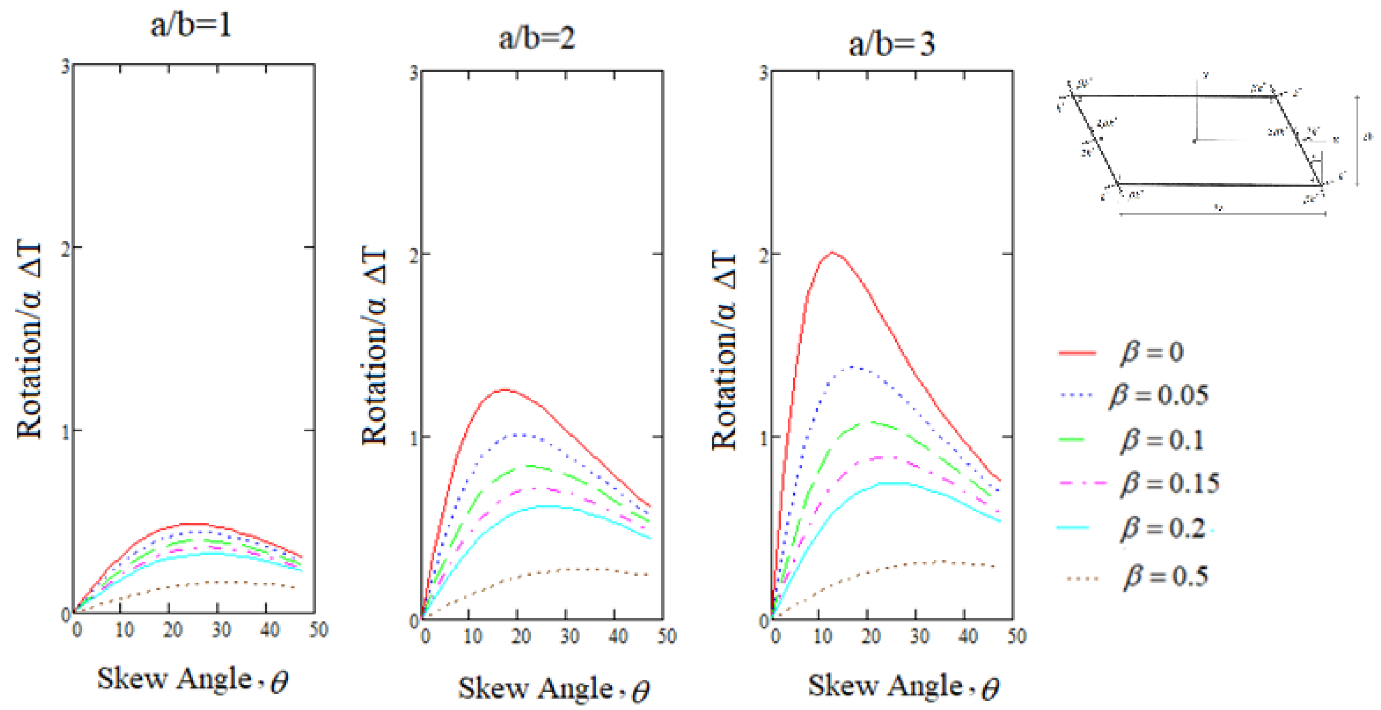

Fig. 3 Variation of in-plane rotation of a skewed rigid plate with θ for a representative range of a/b and β

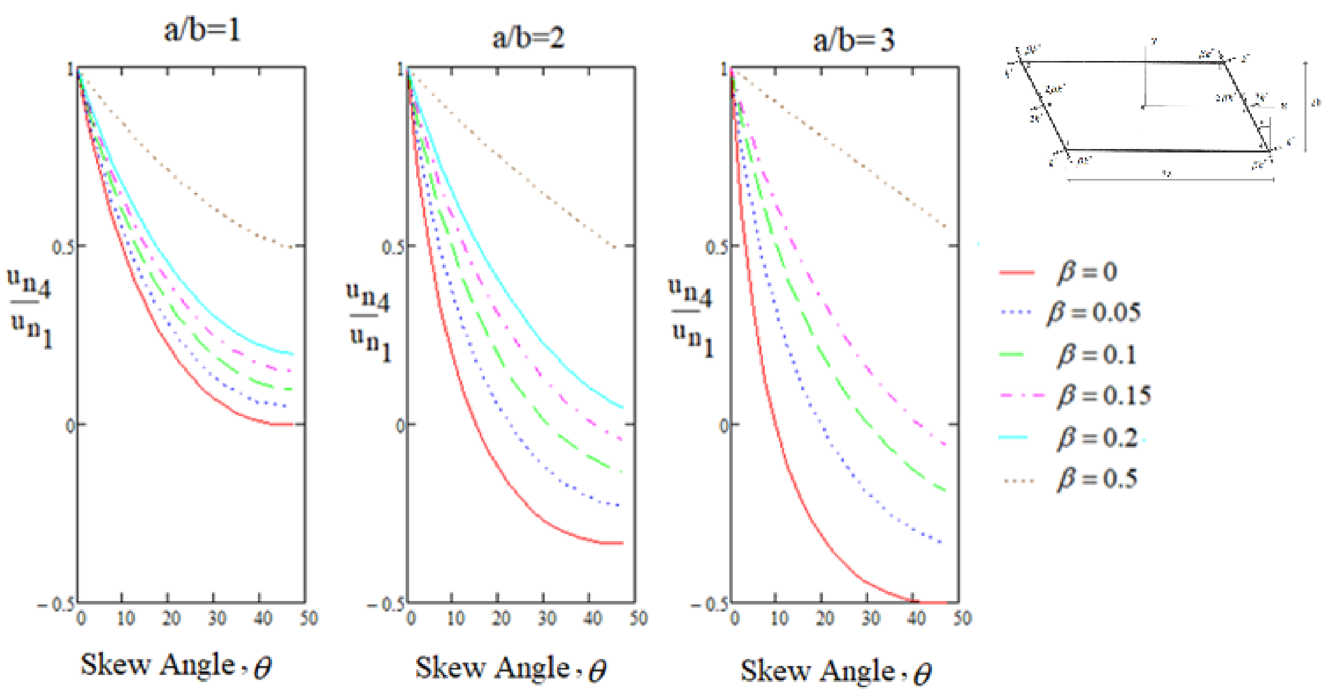

Fig. 4 Variation of ratio of normal displacement at the acute corner to normal displacement at the obtuse corner of a skewed rigid plate with θ for a representative range of a/b and β

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

Table 1: Task Progress			
Task Number	**Start Date**	**End Date**	**Percent Complete**
Task 3:	10/1/2019	12/31/2019	80%
Task 4:	10/1/2019	12/31/2019	20%

Table 2: Budget Progress		
Entire Project Budget	**Spend Amount**	**Spend Percentage to Date**

Participants and Collaborators:

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				
Student Name	**Email Address**	**Class**	**Major**	**Role in research**
Hamed Abshari		Doctoral candidate	Civil Engineering	Computer modeling and literature search

Table 8: Research Project Collaborators during the reporting period						
		Contribution to the Project				
Organization	**Location**	**Financial Support**	**In-Kind Support**	**Facilities**	**Collaborative Research**	**Personnel Exchanges**
VTrans	Vermont		x			
Mass DOT	Massachusetts		x			
Maine DOT	Maine		x			

- Vermont Agency of Transportation.
  I have been in contact with Mr. James Lacroix (the project's champion), State Bridge Design Engineer, Vermont Agency of Transportation, via telephone discussions and email exchanges.

- Massachusetts Department of Transportation.
  I have been in contact with Mr. Alexander Bardow, State Bridge Engineer for the Mass DOT, via telephone calls, email exchanges, and meetings.

- Maine Department of Transportation
  I have been in contact with Mr. Dale Peabody, Director of Transportation Research for the Maine DOT,
  via a telephone call and email exchanges.

Changes:

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

Planned Activities:

- Paramedic study of effect of the type of wing walls (U-wall, Flared wall, and in-line-wall) on the behavior of skew IABs under thermal loading;
- Continue with analytical study of skewed rigid plate;
- Comparison of the results of the analytical study with those of the finite element modeling of sample bridges;
- Presentation of seminar to BSCES/ASCE in April of 2020;
- Continue working on paper to be submitted to refereed journal within the next six months;
- Development of the full three dimensional finite element models of the additional IABs to be provided by Mass DOT.