

**TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT**

Lead Agency (FHWA or State DOT): Kansas DOT

INSTRUCTIONS:

Lead Agency contacts should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # TPF-5(392)	Transportation Pooled Fund Program - Report Period: <input type="checkbox"/> Quarter 1 (January 1 – March 31) <input type="checkbox"/> Quarter 2 (April 1 – June 30) <input type="checkbox"/> Quarter 3 (July 1 – September 30) <input checked="" type="checkbox"/> Quarter 4 (October 1 – December 31)	
TPF Study Number and Title: TPF-5(503) and Standardizing Rigid Inclusions For Transportation Projects: Phase I		
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Lead Agency Project ID: Click or tap here to enter text.	Other Project ID (i.e., contract #): Click or tap here to enter text.	Project Start Date: 7/1/2023
Original Project Start Date: Click or tap to enter a date.	Original Project End Date: 6/30/2025	If Extension has been requested, updated project End Date: Click or tap to enter a date.

Project schedule status:

<input checked="" type="checkbox"/> On schedule	<input type="checkbox"/> On revised schedule	<input type="checkbox"/> Ahead of schedule	<input type="checkbox"/> Behind schedule
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Overall Project Statistics:

Total Project Budget	Total Funds Expended This Quarter	Percentage of Work Completed to Date
\$240,000	\$14,081.53	22%

Project Description:

Rigid inclusions are grouted or cemented columns used to improve loose or soft soils. They have been increasingly used in practice in the United States, mostly for embankment, retaining walls, and box culvert support in transportation applications. Several types of equipment and methods are available in the practice to install rigid inclusions with different trade names. Installation of rigid inclusions may cause full or partial displacement of their surrounding soils that disturb soils, neighboring rigid inclusions, and/or existing structures, depending on the type of equipment and method used, installation procedure, and type of soil. Rigid inclusions are often installed under a load transfer platform to support embankment or structure loads. The methodology and equipment-driven installation has been closely guarded and much is proprietary (commercial competitive advantage), which has left the DOTs dependent on and obligated to the contractor. No well-accepted design methods and construction specifications are available to assess and consider installation effects on their surrounding soils, neighboring rigid inclusions, and nearby existing structures, down drag forces in rigid inclusions under embankment or structure loads, and stability of embankments with side slopes supported by rigid inclusions. Research, including the state of the practice (Phase I) and full-scale field tests (Phase II), is needed to quantify rigid inclusion installation effects, develop design methods considering their effects on load transfer analysis, axial load capacity, and displacement calculations for vertical loads and evaluating the stability of rigid inclusion-supported embankments, and develop construction specifications for minimizing installation effects and improving long-term performance.

The main objectives of the Phase I study are to assess the state of the practice of rigid inclusions used for embankment and structure support, analyze existing data and design methods available in the literature or agencies, identify knowledge gaps and missing data and procedures, and develop a plan for full-scale field tests to be carried out in the Phase II study.

Tasks for this study include:

- 1) Literature Review and Assessment of Current Practices
- 2) Evaluating design methodologies
- 3) Developing a Full-scale Field Test Program

Progress this Quarter

(includes meetings, work plan status, contract status, significant progress, etc.):

The research team continued collecting references including case studies about the current practice of rigid inclusions in projects and performing further literature review. The research team organized a virtual meeting with three consultants and KDOT engineers to give updates and seek inputs about findings from the literature review and the draft questionnaire for an online survey. After the meeting with the consultants, the research team organized a virtual meeting with the steering committee to give them updates and seek their inputs about the findings and the questionnaire. The research team also reached out the experts in the field to seek their inputs on the questionnaire. The questionnaire for the online survey has been finalized for distribution. In addition, the research team was in the process of upgrading the software for numerical analysis.

Task 1: Literature Review and Assessment of Current Practices
The literature review work has been mostly done.

60% COMPLETE

Anticipated work next quarter:

The research team will distribute the survey questionnaire among state DOTs, designers, and contractors, collect the survey responses, and perform statistical analysis of survey data. The research team will share and discuss the survey data and analysis with the consultants and KDOT engineers and seek for their inputs. After the meeting with the consultants, the research team will organize a virtual meeting with the steering committee to go over the survey data and analysis. Task 1 will be completed at the end of next quarter.

The research team will start to evaluate the design methodologies including numerical analysis of selected case studies as compared with the design methodologies.

Significant Results:

The literature review shows that different types of rigid inclusions have been used in the practice. There is no consensus on the definition of rigid inclusions. Rigid inclusions are typically designed as a system, which includes rigid inclusion elements and a load transfer platform. Much research has been done on load transfer mechanisms (soil arching and tensioned membrane) and critical heights above rigid inclusions to prevent differential settlement. A large number of methods including analytical and numerical methods are available to design load transfer platforms above rigid inclusions but these methods often yield significantly different results. Several studies examined the accuracy and differences of these design methods. However, limited research has been done on installation effects and slope stability of embankments supported by rigid inclusions. Recent projects have used a small area replacement ratio (less than 5%) for rigid inclusion elements. Rigid inclusion elements subjected to lateral loads and need for steel reinforcement have become a concern for some projects. How to consider lateral loads in design still requires further research.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

No challenges have been encountered so far that might affect the completion of the project within the time, scope, and fiscal constraints set forth in the agreement.

Potential Implementation:

Not yet.