



# RTI Semi-Annual Progress Report

Fiscal Year 2004

Date of This Report: August 2, 2004 Project Number: 0-4569 RMC: 5

Period Covered by This Report: March 1 – August 31, 2004

Project Title: Design of Bridges for Security

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## 1. Requested Changes for Possible Project Modification

Project Termination: No changes in the project termination date of December 31, 2004 are requested.

Project Personnel: Joseph Gannon, a graduate research assistant currently working on the project, will be completing his M.S. degree in August 2004. Following graduation, he will act as a project advisor.

Funding Needs: No change in total funding level is needed.

Work Plan: No change.

Deliverables Table: No change.

## 2. Program Development Information

This project will end on December 31, 2004

## 3. Equipment

No equipment was purchased during the time period covered by this report.

## 4. Progress to Date, by Task

### Task 1: Literature Review

A complete draft of the literature review has been developed, and a final draft has been submitted to TxDOT in the Phase I Research Report. The report contains sensitive information regarding the behavior of different bridge systems subjected to a variety of terrorist threat scenarios. Specific details, however, have been omitted from the report so that it can be distributed to individuals interested in the research without concern that the information can be used unscrupulously.

## **Task 2: Example Calculations**

Task 2 has been completed, and sample calculations for a typical Texas highway overpass bridge have been included in the Phase I Research Report. As indicated under Task 1, specific details have been omitted so that sensitive information can be kept safeguarded.

## **Task 3: Develop a Plan to Investigate Cost-Effective Measures to Improve Bridge Security**

This Task has been completed. A description of this Plan appears in the Phase I Research Report. The Plan included in this report reflects feedback obtained from the Project Advisory Panel as well as TxDOT personnel.

## **Task 4: Present Literature Review Results**

Results from the research completed under Phase I of the project were presented at two separate meetings. The first meeting took place on August 15, 2002, and the audience consisted of TxDOT personnel only. Following the presentation, TxDOT personnel provided feedback on the work that had been conducted, and all recommendations were integrated into the documentation describing Tasks 1-3.

A second meeting to present the results of the Phase I research occurred on September 10, 2002. Personnel from various state DOTs were present. The purpose of this second meeting was to describe the research completed on the project and to solicit input and funding from other states that are interested in the current research. As a result of the September 10, 2002 presentation and discussion, Phase II of the project has gone into a "pooled-fund" status, and six other states are providing financial support for the research.

## **Task 5: Develop Guidelines to Implement Cost-Effective Measures to Improve Bridge Security**

Task 5 broadly addresses the scope of work to be conducted under Phase II of the research. In order to provide more focus to the Phase II research activities, a specific Phase II Work Plan has been developed and approved by TxDOT. This plan consists of five main sub-tasks. These sub-tasks are described below along with the work completed to date on each sub-task.

### **Task 5a: Identify Five Representative Bridges for Analysis**

This sub-task is complete. The five categories of bridge construction that are being studied during Phase II include the following: 1.) prestressed concrete girder bridge, 2.) steel plate girder bridge, 3.) segmental box-girder bridge, 4.) steel truss bridge, and 5.) cable-stayed bridge. Representative bridges from these five general categories are currently being evaluated. The primary design parameters affecting the behavior of each of these bridge types have been identified for various threat scenarios.

### **Task 5b: Perform a Risk Assessment and Vulnerability Analysis for Representative Bridges**

This sub-task has been completed. The most probable courses of action against each category of bridge construction have been identified and rank ordered.

### **Task 5c: Develop Risk Management Strategies**

Work on this task is still ongoing. Using the list of design load cases developed in Task 5b for each bridge type, the possible effects of these loads on the five categories of bridges have been identified. Structural retrofits and design approaches which possess the potential to effectively counter each specific load effect were then developed. A chart was created showing the load cases, retrofits, and application by bridge type. Refinements to the developed risk management strategies will continue throughout the duration of the Phase II research.

### **Task 5d: Investigate Structural Modifications to Improve Bridge Safety**

For this task, structural models which can be used to perform computer-based analyses have been formulated. Each model represents a particular structural component under specified load scenarios and failure modes. Load cases involving coupled failure modes are not being considered due to the simplistic nature of the models used and the amount of time available to perform the analyses.

To date, significant progress has been made in modeling three of the five categories of bridges being studied on this project. Specifically, analyses of the steel plate girder, prestressed concrete girder, and truss bridges are nearly complete. Work is continuing on the modeling of segmental box-girder bridges and on the cable-stayed bridge.

A variety of different software packages are being used on this task including several employed by the Army Corps of Engineers to predict blast loads and structural response. In addition, a multi-degree-of-freedom model has been developed by the graduate research assistant on the project to help validate the results being generated by the simple models being used for the parameter studies. Results to date demonstrate that the simple models do a good job predicting structural performance.

As reported previously, a draft set of performance-based design standards for terrorist threats to bridges has been proposed. The design standard for a given bridge is based on its criticality (as determined by each state DOT), which dictates the performance category under which it falls. These standards establish a baseline threat level for design loads and define the acceptable level of damage under these loads. The design loads and acceptable damage for each category is based on a balanced assessment of the threats, acceptable risks, and available resources.

### **Task 6: Reporting**

The final Phase I Research Report has been submitted. The Phase II Research Report will be available at the completion of the project.

## **5. Progress on Development of “Product” Deliverables**

<b>Product #</b>	<b>Product Description</b>	<b>Progress to Date &amp; Implementation Status</b>
P1	International Literature Review of Research Related to Bridge Security	completed
P2	Example Calculations of Typical Texas Overpass Bridge Subjected to Blast Loads	completed
P3	Work Plan to Implement Phase II Research	completed
P4	Cost-Effective Guidelines to Improve Bridge Security	will be submitted at the completion of Phase II of the project

## 6. Meetings/Conferences

On April 13, 2004, the PI held a conference call with James Ray of the U.S. Army Corps of Engineers. The purpose of the call was to discuss the final decision reached regarding funding for his efforts on the project as well as to solicit his interest in remaining on the Project Advisory Panel. Despite the difficulties encountered in paying James Ray to participate directly on the project, he agreed to continue serving in an oversight capacity.

The PI was invited to make a presentation at Texas A&M University on April 21, 2004 on the topic of infrastructure security. The talk was given to an audience of approximately 75 people including graduate students, undergraduates, and faculty. The talk addressed the similarities and differences in designing structures to resist blast as compared to seismic events. Several of the research findings from the current project on bridge security were discussed.

On June 7, 2004, the PI gave an update on the project status at the RMC 5 meeting held in Austin. Several important project findings were presented, and a description of the research completed to date was provided.

At the AASHTO meeting on Bridges and Structures held on June 21, 2004 in Orlando, FL, the PI was invited to make a presentation on the research completed on the current project to a national audience. The research results were well received and generated many questions from those present at the meeting. As a result of this talk, several participants requested research reports for additional information on the project.

A project meeting is expected to be held on August 3, 2004 to provide TxDOT personnel with a current status report. Feedback from this meeting will be used to guide the final months of research on this project.

Several meetings and phone conferences with the Advisory Panel took place throughout the reporting period. The PI held project meetings with Mr. Kirk Marchand on three separate occasions, and a meeting was held with Dr. Norman Dennis on July 18, 2004.

## 7. Possible Candidates for Formal Presentations at the Upcoming RMC Meeting

The topic of this investigation is currently of great concern to the engineering community and is likely to be of interest to many of those in attendance at the RMC meeting.

## 8. Miscellaneous

Work already completed on this project has led to the development of several technical manuscripts. Within the last year, a paper titled "Risk Management and Design of Critical Bridges for Terrorist Attacks" was accepted for publication in the *ASCE Journal of Bridge Engineering*, the paper "Analysis of Blast Loads on Bridge Substructures" was accepted at the international conference *Structures under Shock and Impact*, and the paper "Analysis and Design of Critical Bridges Subjected to Blast Loads" was accepted for publication in the *ASCE Journal of Structural Engineering*. These papers are bringing recognition to the research being sponsored by TxDOT and the role that Texas is playing nationally in the area of bridge security.

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