Texas Department of Transportation	**RTI** **Semi-Annual Progress Report**	Form SemiAnnl (5/2004) (GSD-EPC)

Fiscal Year **2004**

Date of This Report August 2, 2004 Project Number 9-8132 RMC 5

Period Covered by This Report March 1, 2004 through August 31, 2004

Project Title Florida DOT Bridge Rails

Name	Agency	Phone	Fax	Email
Alberson, Dean (RS)	TTI	979-458-3874	979-845-6107	d-alberson@tamu.edu

1. REQUESTED CHANGES FOR POSSIBLE PROJECT MODIFICATION

Project Duration: *The project is due to complete in August 2004*

Project Personnel: *Dean Alberson is the principal investigator*.

Funding Needs: *The project is currently running under budget. However, there is a modification to the project pending. Therefore, it would be difficult to estimate the funds to be expended through August 31, 2004.*

Work Plan:. *The possibility of a contract modification has been discussed with the Project Director. We would like to request a contract modification. A proposed version of revised work plan is attached. No additional funds are needed or requested in order to accomplish the suggested revisions to the work plan.*

Deliverables Table: *The requested modification is approved would contain changes to the deliverables table.*

2. PROGRAM DEVELOPMENT INFORMATION

Tasks 1 through 4 have been completed. Reports are pending on tasks 1 through 3 and have been completed for task 4. If approved, the pending contract modification would revise Task 5 and add Task 6.

3. EQUIPMENT

No equipment has been purchased.

4. PROGRESS TO DATE, BY TASK

Following the task number (or letter) designation as depicted in the project agreement:

- *Task 1. FDOT 32" Jersey Shape Railing*
  - *A. Completed Construction Jan 03.*
  - *B. Full-Scale crash test Feb 20, 2003.*

- *C. Report is complete and being reviewed by ITEC TTI.*

- *Task 2. 32" Kansas Corral Railing*
  - *A. Literature review completed Jan 2003.*
  - *B. Completed comparative analysis Jun 2003.*
  - *C. Report has been completed by researcher, being reviewed by Safety and Structural Systems staff for content.*

- *Task 3. Design of Deck Overhang*
  - *A. Test apparatus for static testing has been designed and fabricated, Feb 03.*
  - *B. Initial Test Specimen designed, Feb 03.*
  - *C. Static Testing completed Sept 19,03*
  - *Final report in process.*

- *Task 4. Sign Support Testing*
  - *A. Specimens secured Feb 03.*
  - *B. Pendulum Tests Conducted Feb 03.*
  - *C. Report completed Feb 03.*

- *<u>Task 5. Concrete Parapets, Sleeper Slabs and Parapet Orientation</u> (Task would be revised if pending modification request is approved by TxDOT. We are awaiting information from TxDOT)*

  TTI will review standards of TxDOT and other states to determine existing design methodologies for "Sleeper Slabs" and will report on findings. TTI will review the standards of TxDOT and other states regarding orientation of parapets and report on findings.

5. PROGRESS ON DEVELOPMENT OF "PRODUCT" DELIVERABLES

Product #	Product Description	Progress to Date & Implementation Status
P1	Test results of 32-inch New Jersey Safety Shape Railing	Included in 9-8132-R1 This is complete and under review.
P2	Recommended retrofit and replacement schemes for the three variants of 32-inch New Jersey Railing which, as a result of testing, are found to be non-compliant with AASHTO LRFD specifications and/or NCHRP 350 TL-4 requirements	Included in 9-8132-R1 This is product and associated report are in progress and should be ready for TTI Communications review shortly.
P3	Test results of the variant 32-inch Kansas Corral Railing	Included in 9-8132-R2 This is product and associated report are in progress and should be ready for TTI Communications review shortly.
P4	Test results for deck overhang design according to AASHTO LRFD	Included in 9-8132-R3 This is product and associated report are in progress and should be ready for TTI

	specifications	Communications review shortly.
P5	Recommended revisions to AASHTO LRFD specifications for deck overhang design if testing warrants such revisions	Included in 9-8132-R3 TTI is awaiting direction from TxDOT and Florida DOT.
P6	T4 Retrofit Design and Testing Results and Parapet Orientation Simulation Results	Included in 9-8132-R5 This shall be completed during the next reporting period.

6. MEETINGS/CONFERENCES

7. POSSIBLE CANDIDATES FOR FORMAL PRESENTATIONS AT THE UPCOMING RMC MEETING

Premature at this time

8. MISCELLANEOUS

None.

Exhibit B

PROJECT DESCRIPTION

Project Abstract

Florida Department of Transportation (FDOT) has identified six (6) areas of transportation safety that require further research.

1. FDOT has extensive Jersey shaped barrier in use on highways today. A number of the designs from previous years have minimal reinforcement and when the current design procedure is used to evaluate the respective designs, the analysis indicates marginal performance may be anticipated when impacted by an errant vehicle. Therefore, FDOT has elected to full-scale crash test the most critical design currently deployed in the field.

2. The second area of research need is to evaluate one existing variant of the 32" Kansas Corral Railing to determine compliance status with the *AASHTO LRFD Bridge Design Specifications* and *NCHRP Report 350*, Test Level 4 criteria. This task is to accomplished by comparison to existing crash tested designs and if warranted, a full-scale crash test to verify acceptable performance.

3. Current design procedures outlined in *AASHTO LRFD Bridge Design Specifications* specify a minimum thickness of the cantilevered portion of the bridge deck based on the strength of the bridge railing. FDOT desires to investigate failure modes of bridge railings and decks when thinner decks are used.

4. FDOT currently uses aluminum directional slip bases for small and medium size sign supports. The bases have not been full-scale tested for proper activation.

5. FDOT has a pending issue that they desire to investigate. Parapet orientation relative to the bridge deck or relative to a horizontal plane requires further evaluation. Sometimes parapets are oriented perpendicular to the deck or sometimes they are installed plumb with the earth. Investigation of other states and recommendations are desired.

6. FDOT has pending projects that require an aesthetic TL-4 bridge railing. TxDOT has previously tested the F411 Bridge Rail to TL-3 under previous contract and has approved the testing of the installation under this contract. This task is the full-scale crash test of the F411 to TL-4.

Background and Significance of Work

This project addresses three separate design issues under each of the tasks. Therefore, the associated Background and Significance of Work is addressed by Task.

Task 1

The AASHTO LRFD Bridge Specification Section 13 sets forth test levels and the required test conditions for demonstrating that a bridge rail meets a certain test level. The Appendix to Section 13 gives guidelines for designing bridge rails that will perform satisfactorily in full-scale crash tests. The Appendix to Section 13 is not mandatory. Bridge rails may be designed by other methods and would be considered acceptable if the rail performed acceptably in crash tests.

Ultimately a bridge rail should contain and redirect errant vehicles with minimal damage to the bridge structure. A number of different types of concrete safety shaped bridge rails are used by most states. Over the years a number of different reinforcement schemes have been used and most have withstood the rigors of the highway environment. One end of the spectrum for steel reinforcement in concrete barriers is the Ontario "Tall Wall" (1). The Ontario "Tall Wall", was a safety shaped median barrier that was successfully crash tested with an 80,000lb tractor/trailer and no steel reinforcement was used in the system. A common safety shape bridge rail used extensively in Texas is the T501. The T501 uses a moderate amount of steel reinforcement. Other barriers use extensive steel reinforcement. Obviously reinforcement schemes may vary significantly and still achieve the objective, to contain and redirect errant design vehicles.

As experience is gained with bridge rails, designs change. The geometry such as height, shape, and openness, may change due to vehicle mix, vehicle design changes or public opinion. However a move to a new design doesn't necessarily negate the usefulness of older systems. Or an upgrade in design doesn't automatically indicate the older system will not perform acceptably when impacted under design conditions. The safety performance of bridge rails is ultimately evaluated by a performance based test, i.e. a full-scale crash test.

1. K.K. Mak, W. L. Campise, *Test and Evaluation of Ontario "Tall Wall" Barrier with an 80,000 –Pound Tractor-Trailer*, Texas Transportation Institute, Contract No. 4221-9089-534 for Ontario Ministry of Transportation, College Station, Texas, 1990.

Task 2

The AASHTO LRFD Bridge Design Specifications give guidance on geometry of the traffic face of railing that can be expected to provide acceptable performance in full-scale crash tests. The relationships between geometric factors and performance are approximate and are based on information available at the time the Specifications were prepared. Since that time, many tests of bridge railings have been performed. Testing on post and beam type systems with full-sized pickups has shown the propensity of the front tire and rim to go under horizontal beam elements and snag on support posts. Therefore sufficient post offset, post shape and/or post protection must be considered in safety performance design of these systems.

Task 3

The provisions of Section 13 of the AASHTO LRFD Specifications are based on the assumption that the yieldline failure pattern is confined to the concrete parapet and does not extend

into the bridge deck. In the event that the yieldline pattern extends into the deck, the equations for strength of the system will not be correct. By the nature of the shape, the Jersey and F shaped bridge rail will have a significant increase in moment capacity towards the bridge deck. This large moment capacity at the base, according the design procedures outlined in AASHTO LRFD Bridge Design Specifications, dictates a deck moment capacity to withstand the same moment. Full-scale crash testing of safety shapes on 7 and 8 inch thick bridge decks has not produced a failure in the deck. It is likely the large base of the safety shape isolates the bridge deck from a yield line failure.

There is argument for the philosophy that structural failure, in the event that such occurs from excessive load caused by an excessively severe collision, should be restricted to the parapet and not be allowed to extend into the bridge deck. Presumably, a structural failure that extends into the deck would be much more catastrophic and costly to repair than one that would be confined to the parapet only. On the other hand, one could argue that in an extremely severe collision, structural failure of the deck could be acceptable if sufficient cost savings could be accrued if a lighter system performed acceptably without damage in most collisions.

A further argument can be made based on the philosophy that the parapet and the deck should each be designed to carry the design load without undue conservatism and without regard to the manner in which the structure would fail in the event that an excessive overload would occur.

Pendulum testing as well as full-scale crash testing has been used extensively by TTI in the performance evaluation of various bridge parapets and bridge decks. Deck failures occur in post and beam systems. Steel post and beam systems produce the largest deck failures due to concentrated loads at and around base plate attach points. Continuous concrete bridge parapets almost always have cracking and spalling confined to the parapet.

Task 4

TTI will perform pendulum tests on critical aluminum slip base configurations and extrapolate high speed performance per FHWA high speed extrapolation procedure

Task 5

TTI will review the standards of TxDOT and other states regarding orientation of parapets, will do comparative simulations and will submit a report on findings.

Task 6

TTI will conduct TL-4 test on TxDOT F411 Bridge Rail and submit a report on the findings.

Implementation (Application of the Research Results)

Reports of findings will be provided for all tasks. The results of the first two tasks will verify acceptable performance of both the minimally reinforced Jersey barrier and the modified Kansas Coral railing. If both railings perform acceptably, no remedial measures will be required by FDOT. If unacceptable performance is determined, remedial measures may be required to improve the safety performance of the railings. Task 3 will yield a determination of the acceptable performance of the thinner bridge decks when used in conjunction with F-shape and Jersey shaped railings. If the performance is acceptable, a design methodology will be provided. Unacceptable performance will indicate the design procedure outlined in *AASHTO LRFD Bridge Design Specifications* should be retained and used on all future designs.

The Work Plan

Task 1: FDOT 32-inch Jersey Shape Railing

The objectives of Task 1 are:

1. Determine if any or all of the three subject variants of the 32" New Jersey Shape Railing comply with the requirements of the *AASHTO LRFD Bridge Design Specifications* and *NCHRP Report 350*, Test Level 4.

2. For any of the railings that do not comply with the requirements of Step 1, provide recommended retrofit schemes, if deemed technically and economically feasible, to bring the railings into compliance. Full or partial replacement schemes may also be recommended as appropriate.

3. Prepare a comprehensive report of the research findings and recommendations that is suitable for submittal to the FHWA by the FDOT as part of a request for acceptance package.

The most direct approach for accomplishing the objectives of this task is to perform a full-scale crash tests of the weakest railing design. If that railing performs acceptably, the railing would be acceptable by AASHTO LRFD Specifications. The test that is needed is the strength test for the test level of interest; in this instance, test 4-12, a single-unit van-type truck weighing 8000kg.

The next issue is the point of impact that should be chosen. The researchers understand the reinforcement used in the each of the three variants is uniform in size and spacing throughout the length of a railing installation. That is, additional reinforcement is not used near the end of the railing to strengthen the end. This would make the railing less capable of withstanding an impact near the end of the railing. However, the researchers recommend that the first test be performed with the impact point along mid-length of the tailing. This test will prove or disprove the basic railing is adequate for test level 4. In the event the basic railing is adequate, the second test will be performed with the impact point near the end so as to determine the adequacy of the end segment of the railing.

A technical report documenting the results and conclusions of the testing will be prepared and submitted to FDOT.

Task 2: 32-inch Kansas Corral Railing

The objectives of Task 2 are:

1. Determine if the subject variant of the 32" Kansas Corral Railing complies with the requirements of the *AASHTO LRFD Bridge Design Specifications* and *NCHRP Report 350*, Test Level 4.

2. Prepare a comprehensive report of the research findings that is suitable for submittal to the FHWA by the FDOT as part of a request for acceptance package.

Information from recent tests will be compiled and compared with the geometry of the Corral Railing and with provisions of the AASHTO LRFD Specifications to provide insight concerning acceptability of the geometry of the Corral Railing. If those comparisons indicate acceptability of performance, the researchers will work with FDOT and FHWA to gain approval of the current design without further testing.

If those comparisons are not conclusive, full-scale crash testing of the most critical geometry will be performed at the sole discretion of Florida DOT. One full-scale test with an 820C vehicle would be sufficient to demonstrate acceptability of the geometry of the existing design. A technical report documenting the results and conclusions of the test will be prepared and submitted to FDOT.

Task 3: Design of Deck Overhang

The objectives of Task 3 are:

I. Determine if the requirements for deck overhang design of the *AASHTO LRFD Bridge Design Specifications* are valid in cases such as this.

II. If Step 1 is not valid, recommend revisions to the *AASHTO LRFD Bridge Design Specifications* requirements for deck overhang design that reflect the research findings.

III. Prepare a report of the research findings and recommendations that is suitable for submittal to the FHWA and AASHTO by the FDOT.

The question being addressed in this task involves both technical matters and policy matters. The researchers do not propose to answer the philosophical question in this work but to develop sufficient technical information to allow others to choose the approach that best addresses the situation.

The question to be addressed in this task is the magnitude of bending moment for which the bridge deck should be designed. Should the deck be designed for the moment capacity of the barrier at its base? Or, should the deck be designed for the average bending moment over the height of the barrier? (The bending moment value used to calculate the strength of the barrier) Or, should the deck be designed to resist some other value of bending moment?

This question will be addressed through a series of static load tests and analyses using a finite element stress analysis program.

One series of tests will be designed to determine the failure pattern that will occur in a static load test of a segment of traffic barrier and bridge deck overhang wherein the bridge deck overhang is designed to resist the average cantilever bending moment capacity of the traffic barrier. A suitable length of bridge deck overhang with traffic barrier will be designed and constructed for structural

load testing. The length of specimen to be constructed will be sufficient to remove end effects. That is, the length will be sufficient to cause the failure pattern to be confined within the length and not extend out the ends of the specimen. If a specimen is excessively short, a straight longitudinal yieldline will form in the deck (or barrier) and the desired information will not be obtained.

Three test specimens will be statically loaded (at mid-length of the barrier) to failure with observations of the magnitude of force and the pattern of yieldlines being observed and noted. These test results should provide a definitive answer to the question of whether failure will occur first in the deck or in the barrier.

A stress analysis of the specimen will be performed using a finite element program and the results will be compared with the tests. The stress analysis will result in stress (bending moment) contours for the barrier and deck overhang which will facilitate further development of design equations.

Three other test specimens will be loaded (at the end of the barrier) to failure with the same observations as above being made. These test results demonstrate the type of failure mode for transverse loads applied at the end of the barrier or at a joint in a barrier.

A second series of tests will be designed with a different relative magnitude of bending moment capacity in the deck overhang. The value of design bending moment to be used for the deck will be based on the results of the first series of tests and might be higher or lower than the deck design bending moment used in the first series.

The second series of tests will include the same loadings as the first series and the same stress analysis will be performed.

Collectively, these two series of tests and accompanying stress analyses are expected to provide a clear understanding of structural behavior of a concrete barrier and deck overhang and should provide definitive information for selection of a design procedure barrier/deck structures.

Task 4: Uni-directional Slip Base Performance Verification

TTI will perform pendulum tests on critical aluminum slip base configurations and extrapolate high speed performance per FHWA high speed extrapolation procedure. A report of findings indication compliance or non-compliance with NCHRP Report 350 will be generated.

Task 5: Concrete Parapets with TxDOT T4 Retrofit and Parapet Orientations.

TTI will review the standards of TxDOT and other states regarding orientation of parapets, perform comparative simulations and will report on findings.

Task 6: TL-4 Testing of TxDOT F411 Bridge Rail.

The results of the full-scale crash test will be reported. If performance is acceptable, the F411 bridge rail design will be incorporated into standard design details for use on the state highway system.

Computer Programs

No computer programs will be developed as part of this research.

Assistance or Involvement by TxDOT

There is no assistance or involvement by TxDOT anticipated other than that normally provided by the PD.

Project Deliverables

Deliverables Table
Project No. 9-8132

Products:

No.	Product Description	Required Submittal Date*	Responsible Party for Multi-Agency Agreement	Comments
P1	Test results of 32-inch New Jersey Safety Shape Railing	9/30/03	TTI	Included in 9-8132-R1
P2	Recommended retrofit and replacement schemes for the three variants of 32-inch New Jersey Railing which, as a result of testing, are found to be non-compliant with AASHTO LRFD specifications and/or NCHRP 350 TL-4 requirements	12/31/03	TTI	Included in 9-8132-R1
P3	Test results of the variant 32-inch Kansas Corral Railing	10/31/03	TTI	Included in 9-8132-R2
P4	Test results for deck overhang design according to AAHSTO LRFD specifications	10/31/03	TTI	Included in 9-8132-R3
P5	Recommended revisions to AASHTO LRFD specifications for deck overhang design if testing warrants such revisions	10/31/04	TTI	Included in 9-8132-R3
P6	T4 Parapet Orientation Simulation Results	10/31/04	TTI	Included in 9-8132-R5
P7	TL-4 Full-Scale Crash Test of TxDOT F411 Bridge Rail	108/31/04	TTI	Included in 9-8132-R6

Reports: This table will include a minimum of one Research Report, which comprehensively documents the project, and one Project Summary Report of a maximum of four pages (approximately 1,500 to 2,500 words). The requirements for reports in this table may be revised at a later date by mutual agreement of the Research Supervisor, the TxDOT Project Director, and the Director of TxDOT's Research and Technology Implementation Office. If the report will contain one or more of the products listed above, then state in the comments section which products (by product number) will be included in the report.

No.	Report Description	Required Submittal Date*	Responsible Party for Multi-Agency Agreement	Comments
R1	Research Report containing documentation of the research performed in Task 1.	12/31/03	TTI	includes P1 and P2
R2	Research Report containing documentation of the research performed in Task 2.	10/31/03	TTI	includes P3
R3	Research Report containing documentation of the research performed in Task 3.	10/31/03	TTI	includes P4 and P5
R4	Brief Letter of Findings containing documentation of the research performed in Task 4.	03/31/03	TTI	
R5	Research Report containing Parapet Orientation Simulation Results	10/31/04	TTI	Includes P6
R6	Research Report containing documentation of the research performed in Task 6.	10/31/04	TTI	Includes P7
PSR	Project Summary Report (PSR) of a maximum of 4 pages Summary of work accomplished, findings and conclusion.	10/31/04	TTI	Summary of significant findings

Date Updated: 7/7/04

Schedule of Research Activities

Project 9-8132		Est. % of Total Budg	FY03												FY04											
	Research Activity		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Task 1	**FDOT 32" Jersey Shape Railing**	30%																								
Task 2	**32" Kansas Corral Railing**	15%																								
Task 3	**Design of Deck Overhang**	28%																								
Task 4	**Sign Support Testing**	3%																								
Task 5	**T4 Parapet Orientations**	10%																								
Task 6	**TL-4 Test of F411**	14%																								

	Original Schedule
	Revised Schedule
	Work Completed