RTI
Semi-Annual Progress Report

Fiscal Year **2006**

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Period Covered by This Report March 1, 2006 through August 31, 2006

Project Title Model Calibrations with Local APT Data and Implementation for Focused Solutions to NAFTA Problems

Name	Agency	Phone	Fax	Email
Tom Scullion (RS)	TTI	979-845-9913	979-845-1701	t-scullion@tamu.edu
Fujie Zhou (CO-PI)	TTI	979-458-3965	979-845-1701	f-zhou@tamu.edu
Cesar Carrasco (CO-PI)	UTEP	915-747-6919	915-747-8037	ccarras@utep.edu
Sheng Hu	TTI	979-458-3965	979-845-1701	j-bu@ttimail.tamu.edu
Soheil Nazarian	UTEP	915-747-6911	915-747-8037	narzian@utep.edu
Roberto Osegueda	UTEP	915-747-7950	915-747-8037	osegueda@utep.edu

1. REQUESTED CHANGES FOR POSSIBLE PROJECT MODIFICATION

   Project Personnel: None.

   Work Plan: The work plan is being modified so that UTEP can continue work on this project.

   Deliverables Table: The deliverable table is being modified so that UTEP can continue work on this project.

   Project Termination: The project termination is being extended to August 2007.

   Project Budget: $36,000 are being added to UTEP budget.

2. EQUIPMENT

   None purchased this reporting period.

3. PROGRESS TO DATE, BY TASK

The research project includes the 20 tasks presented below.

Task 1: Investigation of Type of Truck and Axle Configurations to be used under NAFTA
The various truck types currently used in U.S, Canada and Mexico have been compiled, including vehicle type, axle load, and tire pressure information. Finally, this information has been summarized into a technical memorandum and will be used later in the study to evaluate the impact of the different truck types on typical US highways.

Task 2: Predictions of Pavement Damage using the VESYS calibrated with the US281 APT data from Texas
Most of the activities in last reporting period were focused on this task. The research team reviewed the VESYS program and a sensitivity analysis was completed to ensure that the model predictions were reasonable. The result shows that the VESYS program has the potential ability to predict accurately the pavement performance. Furthermore, a full case study was conducted to show how VESYS was calibrated from the performance data collected under the Texas MLS accelerated test program on US281. Material properties were backcalculated from the measured layer rutting. They appeared to be reasonable.

The backcalculated ALPHA and GNU parameters on US281 have been used to calibrate the lab test results. The associated shift factors for lab determined ALPHA and GNU have been established. Based on this previous research results, two case studies (US281N and US281S) have been conducted during this reporting period and the over damage caused by overload and heavy truck has been discussed and presented at project meeting in November 2002.

Task 3: Laboratory Testing Program for APT material for input to VESYS
Extensive laboratory testing was conducting on asphalt mixes during last reporting period. We set up the test machine for this study, and developed the test protocol and associated software to post-process the test data. To further evaluate the effectiveness of the VESYS rut prediction approach TTI compared the field performance of different experimental test sections with the laboratory test results performed on field cores. The sections were part of a SPS1 site in South Texas; each had identical traffic loading, with rut depths ranging from 2 to 25 mm. Field studies had confirmed that the rutting was primarily in the HMA surfacing layer. On cores taken from these sections TTI measured the VESYS rutting parameters (ALPHA and GNU) in a repeated load test procedure. In addition, other recommended test methods to characterize the permanent deformation properties of asphalt mixes were also performed. These included the dynamic modulus, resilient modulus, repeated simple shear test at constant height, Asphalt Pavement Analyzer (APA), Hamburg wheel tracking test. Based on the laboratory tests the materials were ranked from best to worst in terms of rutting potential. The VESYS approach was able to rank the sections in an identical order to their actual measured field performance. The VESYS approach was found to be better than the other test methods at matching field performance.

A part of this task Dr. Fujie Zhou from TTI visited the ALF facility in Baton Rouge, Louisiana. Samples of the HMA layers from three different ALF test sections were obtained and tested in TTI to measure both the modulus and permanent deformation properties at three temperatures. These laboratory test results correlated with the ALF test results and the initial FWD measurement.

TTI has purchased (in another project) a new triaxial cell for base testing in previous reporting period. Our laboratory staffs are getting familiar with this system. It tests 6-inch diameter sample (12 or 8'' high), to provide both resilient modulus and permanent deformation properties. The new triaxial cell has been used to characterize permanent deformation properties of asphalt mixture under different load levels and confinements. The results clearly indicate that VESYS rutting parameters (ALPHA and GNU) are stress dependent. Based on the important finding the stress dependent ALPHA and GNU regression equations have been developed for overload-overdamage prediction.

TTI has developed the test protocol for modulus and permanent deformation property of granular base and subgrade soil. The triaxial repeated load cell has been set up for resilient modulus and permanent deformation tests on granular base and subgrade soils. Furthermore, TTI already collected the granular base and subgrade soils from National Pooled Fund Study 208 (NPFS208) site, and conducted the resilient modulus and permanent deformation test. Up to now, TTI has finished the lab test on granular base material and A-4 soil. In addition, TTI has analyzed the NPFS208 APT on A-4 soil. The analysis results further verify that VESYS rutting parameters (ALPHA and GNU) are stress dependent; Increasing the load level results in much deeper rut depth. Further analysis and calibration on other NPFS208 APT site are under way.

Task 4: Pavement Performance Simulation Studies

The overall goal of this study is to use calibrated pavement performance models to estimate the impact of different truckloads on overall pavement performance and repair costs. To demonstrate this approach a case study was conducted to evaluate the influence of different NAFTA trucks on pavement performance. The summarized axle load information from Texas, Mexico and Canada (Task 1) was used in this investigation. This analysis was based on the pavement performance model (VESYS 5) which was calibrated with the accelerated pavement test (APT) data collected with the Texas MLS site.

As the case study, the relationships between overload and over-damage on US281 site has been estimated using the calibrated ALPHA and GNU regression equations. It was found that the rutting would be over-estimated if the 4^{th} power law is used to compute the effect of overload on pavement rutting.

Further analysis on NPFS208 APT data is under way.

Task 5: Support for development of VESYS5 for Windows

As requested by the representatives of participated states, TTI is developing the VESYS5 program for Windows. The new framework of this Windows-version VESYS5 program has been developed. This Windows-version VESYS5 program was presented and accepted by the representatives of participated states in last semi-annual research progress meeting held at Rochester, NY. In addition, the representatives of participated states have asked TTI to further develop the program rather than FHWA.

Much effort has been made in this task. TTI has demonstrated the TTI Windows version of VESYS program on fifth semi-annual research progress meeting in March 2003, Austin. The new enhanced program has user friendly input and out interface. In addition, a hierarchical 2-level input of pavement materials properties has been adopted. Level 1 is designed for important project and pavement materials properties should be characterized in laboratory according to the laboratory test procedures recommended in Task 3. Level 2 will use default

values which have been determined based on the laboratory test results (see task 3) and from existing databases.

Task 6: Finite Element Modeling (UTEP)

As part of this task, a finite element model was developed and optimized. The optimized model was applied to two MLS sites. An animation was developed to demonstrate the process of rutting. The models have been expanded to consider the 3-D and nonlinear nature of the problem at hand. An optimized mesh based on infinite elements to optimize the procedure has been developed. Aside from executing case studies as requested by the pool fund participants, this task is complete.

Task 7: Establishment of Communication Means

As a part of this task, we developed a web page that would allow the participating states observe the progress of the project. The webpage will be updated and upgraded as information becomes available.

Task 8: Selection and Calibration of a Reflection Cracking Model

This task has been dropped by representatives of participated states in May 2002.

Task 9: Implementation Reports and User training

To be started later.

Task 10 Development of Enhanced VESYS5-Window-Version Software

TTI has re-organized the input and output data to provide user a friendly Windows-version VESYS5 interface. The DOS version VESYS5 has been enhanced to include different hierarchical input level. Also, this enhanced Windows-version VESYS5 software has been preliminarily developed and submitted to all participated DOTs and FHWA for evaluation in January 2004. Based on the comments from all participated DOTs and FHWA, TTI has fixed the bugs and the modified VESYS5 was submitted to all participated DOTs and FHWA again in June 2004. A further upgraded version was submitted to all participated States plus Ohio DOT and FHWA for evaluation in late 2004 and early 2005. TTI will formally distribute this software at end of this project.

Task 11 Development of Neural Network-based Prediction Models (UTEP)

A prototype neural network model was developed and demonstrated to the project advisory committee (PAC). In a May 2004 meeting in El Paso, the PAC decided to abandon further development of the neural network models in favor of an efficient finite element code. The code is ready for use at this time for single- and dual-tandem loads.

Task 12 Lab Test on CRREL Base and Soil Materials and Data Analysis

TTI has finished the lab tests proposed to characterize the CRREL subgrade soil materials. Resilient modulus, permanent deformation, and shear strength properties have been determined based on lab test results. The test results have been shared with another national pooled fund study 2-208 project Director Dr. Wes Yang and 2-208 CRREL research group.

Task 13 Laboratory Characterizing Pavement Materials for Each State (Strong Recommendation)

New York State DOT has sent TTI two granular subbase materials. TTI has run a series of lab tests on these two subbase materials. The tests conducted include sieve analysis, moisture-density curve, tube suction, Mr, permanent deformation test. The preliminary test results have been submitted to Dr. Julian Bendana for review. Also, two asphalt mixes and associated asphalt binders from NYSDOT have been shipped to TTI for testing in 2004. The dynamic modulus test required by NCHRP 1-37A Mechanistic-Empirical Pavement Design Guide has been conducted, and test results have been submitted to Dr. Julian Bendana for review. In addition, crack resistance of these two mixes was evaluated by the TTI overlay tester. The corresponding results also were submitted to Dr. Julian Bendana. TTI is willing to characterizing other type of materials from each state.

Task 14 Overload Damage Study

Recently, with guidance and help from project director Dr. Dar-Hao Chen, TTI has analyzed the 208 APT data to determine overload damage on thin pavement. It was found that the well known "4th-power rule" is too conservative for low SN pavements. With 10% overloading, 4th-power rule will underestimate the damage of these light pavements by approximately 68%as compare to those from 8th-power rule.

Task 15 Implementation and Workshop Training (2 days workshop in TTI)

A workshop was provided to DOT representatives at TTI, on September 7-8, 2005.

Task 16 Reports

One research report has been published and submitted to all participated DOTs and FHWA. The second report has been submitted to TxDOT in August, 2004. Research Report 1502-3 was approved and published at UTEP. Research Report 1502-6 was approved and published. All other reports will be presented to TxDOT and sponsoring States at the end of this study.

Task 17 Development of Advanced Overweight Models

The number of axles associated with super heavy loads can be as high as a couple of dozens. A study to determine the best way to simplify the axle configuration without significantly sacrificing the accuracy of the results is progressing as scheduled. A simplified method for predicting the critical stresses for a multi-axial configuration form a dual tandem load has been developed and is currently being tested for accuracy. An efficient 2-D and 3-D finite element is being finalized at this time.

UTEP has developed an efficient and easy to use finite element code for this purpose. The program and the associated user's manuals were distributed for review by the participating states.

NYDOT has provided a GIS database that contains the cross-sections of the pavements and material types. A GIS-based software package that automatically selects the most appropriate route and calculates the associated damage potential has been developed and distributed for evaluation by the participating states.

The software has been modified as requested by the participating states for ease of use.

Task 18 Review and Laboratory Evaluation of FHWA ALF Fatigue Test Sections

In this report period, TTI focused on overlay testing on the cores from FHWA-ALF fatigue test site. The results clearly indicated the overlay tester could be used as a simple performance test for fatigue cracking. The cores needing larger number of cycles to break under the overlay tester had long fatigue life under FHWA-ALF testing in the field as well. In addition, TTI also determined fracture properties of these FHWA-ALF cores using the overlay tester. Finally, TTI researchers predicted the fatigue cracking development with the FHWA-ALF passes based on all available information. Very good predictions were obtained. All these results will be documented in the final TTI report.

Task 19 Additional Laboratory Characterizing Pavement Materials for Texas and New York State

A series of lab testing including dynamic modulus and overlay test on the cores from US83 have been finished. These results will be reported in the final report. Additionally, New York State is planning to send plant mixes to TTI for advanced testing.

Task 20 Reports

Not at this reporting period.

Work plan for next 6 months:

UTEP will continue working on Task 17 as reflected in the latest modification.

4. PROGRESS ON DEVELOPMENT OF "PRODUCT" DELIVERABLES

Product #	Product Description	Progress to Date & Implementation Status
P1	Guideline for developing input and output from selected FE Program	Delivered to RTI by UTEP
P2	Guidelines for developing inputs from laboratory testing for the enhanced VESYS program	Delivered to RTI by TTI
P4	Training sessions to TxDOT and other participating state	Notes submitted in Nov. 2005.
P5	Guidelines for Developing input parameters of enhanced VESYS 5 program	Submitted by TTI
P6	Workshop and training to TxDOT and other Participated states	Submitted 12/13/2005
P7	Enhanced VESYS 5 Window-Version Software	Submitted 11/4/2005
P8	VESYS 5 Software User Manual	Submitted 11/4/2005
P9	The Neural Network Software	Submitted in October 2005
P10	Manual for Neural Network Software	Submitted in October 2005
P11	The Software and associated manuals for Superheavy Load Movement in NY	The evaluation copy was submitted in October 2005. The finalized version will be submitted by 10/31/2006

5. MEETINGS/CONFERENCES

A semi-annul meeting was held at Baton Rouge, LA on May 24-25, 2006. Participated states representatives and TTI Researcher attended this meeting.

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

Not at this time.

7. MISCELLANEOUS

None