AGREEMENT FOR TECHNICAL ASSISTANCE
BETWEEN THE SECRETARY OF TRANSPORTATION
AND THE
Kansas State University

**THIS AGREEMENT** made this 17 day of December, 2004, by and between the Secretary of Transportation of the State of Kansas, hereinafter called "Secretary", and the Kansas State University, hereinafter referred to as "KSU", acting by and through Paul R. Lowe, representative.

WITNESSETH

**WHEREAS,** the **Secretary** has entered into a Memorandum of Understanding to establish the Midwest States Pooled Fund Accelerated Testing Program and to have Kansas serve as lead state, and

**WHEREAS,** the **Secretary** has determined that research regarding accelerated testing for the purpose of studying pavement design and performance is needed and approved

**WHEREAS,** the proposed program is hereinafter called "Project," and

**WHEREAS, KSU** has expressed an interest in performing the research and has qualified personnel with demonstrated expertise available to conduct the Project, and

**WHEREAS,** the **Secretary** is willing, subject to the terms of the **Agreement,** to reimburse **KSU** for the assistance provided.

**NOW THEREFORE** in consideration of the mutual covenants herein contained, the parties hereto agree as follows:

**Section 1.** Scope of Services. The KSU shall furnish the necessary personnel, facilities and such other services as may be required to fulfill the tasks identified and described in the Proposal which is attached hereto and incorporated herein as Special Attachment No. 1.

**Section** 2. Contract Dates. The KSU may commence to work in conformity with the Proposal (Special Attachment No. 1) of the **Agreement** upon acceptance by **Secretary** of the Proposal and shall prosecute the work outlined herein to begin on or after April 1, 2005 and with completion not later than March 31, 2008, unless the time is extended by the **Secretary,** as evidenced in writing.

**Section** 3. Basis of Payment. The **Secretary** agrees to reimburse the KSU for the work completed and actual costs incurred in performance of the **Agreement** in accordance with the proposed budget, page 20 of the Proposal, in an amount not to exceed a total price of $884,362. A combination of Federal monies and KSU matching monies are used to fund this Project. The Project costs referred to in the **Agreement** shall be comprised of the allowable direct costs incidental to the performance of the work described in the Proposal and indirect costs. Indirect costs shall not exceed twenty-six percent of the total allowable modified total direct costs to the extent that Federal-aid funds are used for payment. In the event final approval of Federal appropriation is not obtained, the **Secretary** will be responsible for only those noncancelable obligations incurred by KSU for work under this **Agreement.**

**The Secretary** agrees to make payments to the **KSU** upon presentation of proper billing to the **Secretary.** Certification of work performed will be documented by progress reports required under Section 11 of this **Agreement** to support costs claimed. Upon receipt of monthly expenditure reports, the **Secretary** will reimburse allowable costs as requested by the KSU. The KSU shall indicate on the last project billing that it is the final billing. The final request for payment shall not be disbursed until the **Secretary** determines that all obligations of the **Agreement** have been completed. Reimbursement of any cost pursuant to the **Section** shall not constitute a final determination by the **Secretary** of the allowability of such cost and shall not constitute a waiver of any violation of the terms of the **Agreement** committed by the KSU.

**Written approval by KDOT will be required to extend a completion date or increase the total budget amount. Revisions on line items will not require written approval by KDOT. The Principal Investigator will notify the KDOT Project Monitor of planned changes to the work described in the proposal.**

The test of allowability of a cost to be applied in the **Agreement** is based on the reasonableness of the allocation of the cost under generally accepted cost, accounting principles and practices and in accordance with 48 code of Federal Regulations (CFR), Ch. 1, part 31 et.seq., and relevance to tasks identified and described in the Proposal. However, such costs are subject to limitation as per **Agreement.**

The final payment due under provisions of this **Agreement** shall be made within ninety (90) days after the **Secretary's** and the appropriate Federal agency's acceptance and approval of the Final Evaluation Report and **KSU's** compliance with OMB A-133, Audits of States, Local Governments, and Non-Profit Organizations.

**Section 4.** Covenant Against Contingent Fees. The KSU warrants and guarantees that provisions for covenants against contingent fees found in Special Attachment No. 2 are incorporated in this **Agreement** and made a part hereof. For breach or violation of this warranty, the **Secretary** shall have the right to annul this **Agreement** without liability, or in his discretion to deduct from the **Agreement** price or consideration, or otherwise recover, the full amount of such fee, commission, percentage, brokerage fee, gift, or contingent fee.

**Section 5.** Rights in the Project.

A. Rights in Data. The KSU grants to the **Secretary,** for any governmental purposes, the right to publish, translate, reproduce, deliver, use and dispose of, and to authorize others to do so, all data, including reports, drawings, blueprints, computer software which includes but is not limited to documentation and source code, and other technical information resulting from the performance of work under this **Agreement.** When the **Secretary** authorizes others to use, for governmental purposes, any patented or copyrighted items arising from the project, the **Secretary** will issue a standard restriction **Agreement** to each party receiving authorization for return to KSU.

2. Rights in Intellectual Property. Consistent with KDOT and Kansas Board of Regents policy, the KSU will retain all rights to intellectual property including patents and copyrights arising from the project. The **Secretary** and the **U.S. Government** shall retain a royalty-free, nonexclusive, irrevocable license to use any patent or copyright arising from the project for any governmental purposes. If the KSU elects not to pursue the patenting or copyrighting of intellectual property, the KSU will provide written notification to

the **Secretary** who shall be free to do so. The **KSU** agrees to include, within the specification of any United States patent or copyright application and any patent and copyright issuing, the following statement, "The invention (copyright) was made with funds provided by the Federal government and State of Kansas through the Kansas Department of Transportation."

C. Confidentiality. **Secretary** and **KSU** agree that information exchanged and generated pursuant to this **Agreement,** will generally be non-confidential and suitable for publication. Nevertheless **Secretary,** and its duly authorized representatives may disclose to KSU, during the course of the project, confidential information including data and statistics not suitable for public dissemination. KSU agrees to maintain such information in confidence, and to prevent the disclosure thereof to others to the extent that such information is disclosed in writing and marked as confidential or proprietary; or if orally disclosed, noted at the time of disclosure as being confidential or proprietary, and reduced to writing within thirty (30) days after such oral disclosure, the writing being marked as confidential or proprietary. KSU agrees that neither the KSU nor any of its colleagues, employees or agents shall use any of the confidential information for any purpose whatsoever, other than to complete this agreement for **KDOT**. The **KSU** agrees that the KSU or any of its colleagues, employees or agents shall not keep any copies of the information provided by the **Secretary** or its duly authorized representatives that has been identified as confidential or proprietary, and provided pursuant to this agreement.

D. Rights in Equipment. It is mutually agreed by the **KSU** and the **Secretary** that all apparatus and equipment purchased with funds provided by the **Secretary** shall be used by the KSU for the project and shall become property of the KSU upon completion of the project subject to the following provisions:

1. Those Uniform Administrative Requirements contained in 49 CFR Part 19 shall govern the purchase, use and disposition of equipment covered by this **Agreement.**

2. The KSU will provide first priority to the **Secretary** with right of refusal for testing pavement and/or other structural systems on an at-cost basis.

**Section 6.** Work Responsibility. The parties hereto mutually agree that the services to be performed under the terms of this **Agreement** are to be performed by the Principal Investigator and others named in the Proposal under the guidance and supervision of KSU and that their time and effort as defined in the proposal, Special Attachment No. 1 cannot be assigned, sublet, or transferred to any other party without the written consent of the **Secretary. KSU** accepts full responsibility for the project and its conduct. The KSU will bill **Secretary** for reimbursement as specified in the **Agreement** as awarded.

**Section** 7. Inspection and Approval of Work. The KSU shall permit the **Secretary** or his duly authorized representative to inspect and audit all work, material, computer programs and other data and records either during the performance of project or for three years from the date of the final payment to the KSU under the agreement. All work will be performed according to the requirements as outlined in the Proposal, Special Attachment No. 1. Final Inspection of the Project will be conducted by the **Secretary** or his duly authorized representative.

**Section 8.** Publication Provisions. Publication by any party to this **Agreement** shall give credit to all other parties. However, if the **Secretary** does not wish to subscribe to the findings or conclusions of an interim report, the following statement shall be added: "The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Kansas Department of Transportation or the Federal Highway Administration." In the event of failure to reach a consensus between the **Secretary** and the **KSU** relative to the publication of a final report, or any other reports during the period of the **Agreement, the Secretary** reserves the right to publish independently in which event the nonconcurrence of the **KSU** shall be set forth in said publication, if requested by the **KSU.**

**Section 9.** Audit and Retention of Records. Arrangements shall be made by the **KSU** for the required financial and compliance audit to ensure that the audit will be made within the prescribed audit reporting cycle, and a copy of the OMB A-133 audit will be provided to the **Secretary.**

The **KSU** shall be required to maintain accounting records and other evidence pertaining to the costs incurred and to make the records available to their office at all reasonable times during the **Agreement** period and for three (3) years from the date of the final payment to the KSU under this **Agreement.** Such accounting records and other evidence pertaining to the costs incurred will be made available for inspection by the **Secretary** or his duly authorized representatives and copies thereof shall be furnished if requested.

**Section 10.** Termination of Agreement. Either party has the right to terminate this **AGREEMENT** by giving thirty (30) days written notice in the event a determination is made that the Project should be abandoned or indefinitely postponed; **PROVIDED,** however, that in any case, the KSU shall be paid the amount due for the services rendered and for any noncancelable obligations incurred prior to the date of termination on the basis of the provisions of this **AGREEMENT** and provided that the **Secretary** shall receive full reports of all work performed to the date of termination of this **AGREEMENT.**

**Section 11.** Reports. The **KSU** shall advise the **Secretary** regarding the progress of the Project as such times and in such a manner as the **Secretary** may require, including, but not limited to, the following:

1) a monthly expenditure report, and
2) a quarterly progress report.

**Section 12.** Cooperation and Disputes. The **Secretary** and the **KSU** agree to make a reasonable effort to promptly resolve any disputes or questions concerning the project. The **Secretary** and the **KSU** ensure that personnel will cooperate fully in carrying out the intent and provisions of this **Agreement. The Secretary** shall, in all cases not disposed of by agreement among or between the parties to the **Agreement,** resolve any disputes which may arise in connection with the work being performed under this **Agreement.**

**Section 13.** Compliance with Laws. The **KSU** agrees to comply with all federal, state, and local laws, ordinances and regulations in the implementation of the administrative service provided for in the **Agreement,** including but not limited to 49 CFR part 19, Title VI, Title VII, and Title IX of the Civil Rights Act of 1964, Executive Order 11246 as amended by Executive Order 11375 entitled "Equal Employment Opportunity;" Executive Order 12549 regarding debarment, eligibility, indictments, convictions, or civil judgments; and 31

U.S.C. Section 1352; Section 319 P.L. 101.21 prohibiting use of Federal funds for lobbying activities which are incorporated herein as Special Attachments Nos. 3, 4, and 5, respectively.

**Section 14.** Responsibility to Employees. The **KSU** accepts full responsibility for payment of unemployment insurance, workmen's compensation, and social security as well as all income tax deductions and any other taxes or payroll deductions required by the law for its employees engaged in the work authorized by the **Agreement.**

**Section 15.** Employment of **Secretary's** Employees. The **KSU** will not, without written permission from the **Secretary,** engage the services of any person or persons in the employment of the **Secretary** for any work required by the terms of the **Agreement.**

**Section 16.** Contractual Provisions Attachment. The provisions found in Contractual Provisions Attachment Form DA-146a, Special Attachment No. 6, which is attached hereto, are hereby incorporated in this **Agreement** and made a part hereof.

**Section** 17. Indemnification Agreement. The **KSU** agrees to indemnify and hold harmless the **Secretary** and the **Secretary's** duly authorized representatives from any and all costs, liabilities, expenses, suits, judgments, damages to person or property or claims of any nature whatsoever arising out of the negligent acts of the **KSU,** the **KSU** employees or subcontractors, in the performance of this **Agreement.** The **KSU** shall not be required to indemnify and hold the **Secretary** harmless for negligent acts of the **Secretary** or his or her duly authorized representatives or employees. Nothing in this indemnification clause is meant to affect Section 4 Disclaimer of Liability of DA-146a, Special Attachment No. 6.

**Section 18.** Prohibited Interest. No member, officer, or employee of the **KSU** during his/her tenure or one year thereafter shall have any interest, direct or indirect, in this **Agreement** or the proceeds thereof other than that allowed by the Board of Regents policy.

IN **WITNESS WHEREOF:** the parties hereto have caused this **Agreement** to be signed by their duly authorized officers on the day and year first above written.

**KSU**

Paul R. Lowe AMF 12-10-04

Paul R. Lowe
Assist. Vice Provost for Research

ATTEST

**Secretary**

Warren L. Sick

Debra L. Miller
Secretary of Transportation
By: Warren L. Sick
Assistant Secretary and
State Transportation Engineer

ATTEST

FORM APPROVED BY KSU Legal Dept. DOT

Special Attachment No. 1, Proposal
Special Attachment No. 2, Certification - Covenant Against Fees
Special Attachment No. 3, Civil Rights Act
Special Attachment No. 4, Certification -Debarment
Special Attachment No. 5, Certification - Federal Aid Contracts
Special Attachment No. 6, Form DA-146a

Special Attachment No. 1

PROPOSAL

to

# MIDWEST STATES ACCELERATED PAVEMENT TESTING POOLED FUNDS PROGRAM



for

# VERIFICATION OF MECHANISTIC- EMPIRICAL DESIGN MODELS FOR FLEXIBLE PAVEMENTS THROUGH APT TESTING (CISL EXPERIMENT NO. 14)

**Period of Performance: 04/01/05 - 3/31/08**
**Project Monitor:** ***Andrew J. Gisi, P.E.***
**Funds Requested: $884,362**

**from**

Kansas State University
Fairchild Hall, Room No. 2
Manhattan, KS 66506-1103

K-STATE

**Project Personnel:**

*Stefan A. **Romanoschi, Ph.D.,P.E.***
***Mustaque Hossain, Ph.D., P.E.***
Department of Civil Engineering
Kansas State University
Manhattan, KS 66506-2905.

K-STATE ENGINEERING

**APPROVALS:**

**Stefan A. Romanoschi**
**Principal Investigator**

12-10-04

**Paul R. Lowe**
**Assistant Vice Provost for Research**

## ABSTRACT

This document presents the proposed test plan for the full-scale accelerated pavement test, ATL Experiment No. 14, to be conducted at the Civil Infrastructure Systems Laboratory of Kansas State University during Fiscal Years 2005 through 2007. The experiment was selected by the Midwest States Accelerated Testing Pooled Funds Technical Committee. The pooled funds program is administered by the Kansas Department of Transportation (KDOT) and is supported by the States of Iowa, Kansas, Missouri and Nebraska. The objectives of this experiment are to validate several models incorporated in the NCHRP 1-37A design methods for flexible pavements: the dynamic resilient modulus model, the relationship between the dynamic modulus and the pavement response; the relationship between the pavement response (strains) and pavement performance. In addition to these, the experiment aims to compare the performance of the coarse and fine Superpave mixes, and to validate and calibrate the Asphalt Pavement Analyzer (APA) as a screening tool for estimating rutting performance of Superpave asphalt mixes.

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## I. INTRODUCTION

The *AASHTO Guide for the Design of Pavement Structures* is the primary document used by the state highway agencies to design new and rehabilitated highway pavements. The Federal Highway Administration's 1995-97 National Pavement Design Review found that some 80% of the States make use of either the 1972, 1986, or 1993 AASHTO Pavement Design Guide. All those design guide versions employ empirical performance equations developed using AASHO Road Test data from 1950's. The 1986 and 1993 guides contained some state-of-the-practice refinements in material input parameters and design procedures for rehabilitation design. In recognition of the limitations of earlier Guides, the AASHTO Joint Task Force on Pavements (JTFP) initiated an effort in the late 1990's to develop an improved Guide by the year 2002. The major long-term goal identified by the JTFP was the development of a design guide based as fully as possible on mechanistic principles.

The National Academy of Science through its NCHRP Program (specifically NCHRP Project 1-37A) has dedicated significant resources provided by the AASHTO member states to develop a user-friendly procedure capable of executing mechanistic-empirical design while accounting for local environmental conditions, local highway materials, and actual highway traffic distribution by means of axle load spectra. Since the resulting procedure is very sound and flexible and it considerably surpasses any currently available pavement design and analysis tools, it is expected it will be adopted by AASHTO as the new AASHTO design method for pavement structures. It is also expected that the Department of Transportations in the four Midwestern States, Kansas, Iowa, Missouri and Nebraska, will adopt the new AASHTO design method to replace the 1993 AASHTO design method currently in use.

It should be noted that all mechanistic design approaches produce *"theoretical structural designs"* that should be adjusted or *"calibrated"* to actual conditions using data originated from in-service pavement structures. Although calibration should be incorporated in the new AASHTO design procedure, it is to be remembered that it is a procedure with (i) national correlations to estimate selected inputs; (ii) national default values; and (iii) national calibration factors developed from the LTPP sites (7). It is clear that all these need to be validated and/or calibrated for the specific state and/or region. Without region/state specific calibration, the new guide will be ineffective and of limited use for design purposes. Also, assessment of the design reliability can only be attempted after the guide has been calibrated and validated.

The products of the NCHRP Project 1-37A are the design software and the documentation supporting the design guide. They were released to the pavement engineering community in June 2004. For successful application of the new AASHTO design method to local conditions, this specific calibration strategy should address all main aspects of pavement performance and economic analysis: (1) characterization of pavement materials and soil, (2) traffic loading, (3) environment conditions, (4) field calibration, (5) design reliability, (6) alternative surface type consideration and (7) life cycle cost (LCC) analysis. Even before the final software version and documentation was released, each of the four states has allocated resources to calibrate the models for regional/state conditions. The calibration task is complex, requires significant resources and time.

The calibration of design model for flexible pavements encompasses three major tasks:
1 - verification of the models to predict mechanical properties of pavement materials from conventional, local material properties as follows:

- dynamic modulus for asphalt concrete from binder viscosity and aggregate gradation, and resilient modulus
- resilient modulus of unbound materials from gradation, or classification data
- elastic modulus of stabilized materials from compressive strength data

2 - verification of the mechanistic structural model, that calculates the response (stresses, strain and deflections) of the flexible pavement structure under a given wheel loading for a given pavement structure, with known layer thickness and material stiffness;

3 - verification or calibration for local pavement configurations of pavement performance models or transfer functions, the empirical functions that relate the distresses in the pavement structure to the magnitude of the pavement response.

This research work aims to contribute to the first three tasks: the verification and calibration of material characteristics prediction models, mechanistic structural models and pavement performance models by conducting Accelerated Pavement Tests at the CISL Laboratory of Kansas State University. Due to the limited number of pavement sections that can be constructed and tested at CISL, the research work will focus on the verification of the NCHRP 1-37A models for flexible pavement structures in the four Midwestern states- Iowa, Kansas, Missouri, and Nebraska.

# II BACKGROUND

## a. Accelerated Testing Laboratory (ATL)

The Department of Civil Engineering, Kansas State University, in cooperation with KDOT has developed the Civil Infrastructure Systems Laboratory (CISL). The facility allows the development of full-scale accelerated tests on pavement structures, by using the ATL machine as the loading device. The loading device is placed on a full-scale road structure constructed in a pit. A full-size truck axle passes over the pavement at about every five seconds, applying a total axle load between 9 and 18 kN. The system relies on an air bag suspension placed between the axle and a metallic reaction frame in which the air pressure can be automatically controlled. When air is compressed in the airbag, the generated reaction force between the frame and the suspension is transmitted to the pavement. Both single and dual tires, single and tandem axles can be accommodated in this system.

The major benefit of the tests developed at the ATL is that the performance of road materials and structures can be evaluated at a reduced cost and in a short period of time, since the cumulative traffic passing on an in-service road section in ten years will be applied here only in several months. The ATL facility allows control and monitoring of the temperature at the surface and in the pavement layers. This assures that the pavement materials and structures are subjected to identical load and environmental conditions.

## b. The NCHRP 1-37A Design Guide and Models for Flexible Pavements

### *b1. General framework of the Guide*

The design approach to be provided in the Guide is summarized in Figure 1. The activities are divided into three major parts:

Part 1 consists of the development of input values for the analysis. A key step of this process is the foundation analysis. For new pavements, the foundation analysis consists of strength and stiffness determination and, where appropriate, an evaluation of volume change, frost heave, thaw weakening, and drainage concerns. As part of the foundation analysis, subgrade improvements such as strengthening and drainage are considered.

The foundation analysis for rehabilitation projects also includes a subgrade analysis. However, the most important part of the foundation analysis for rehabilitation projects is the investigation of distress types occurring in the existing pavements and the underlying causes of those distresses. The overall strength/stiffness of the existing pavement is evaluated using deflection testing and back-calculation procedures.

Also during the first stage, pavement materials characterization and traffic input data are developed. The FHWA Integrated Climate Model is used to develop climatic inputs for the foundation and materials analysis and the pavement response analysis in Part 2.

In the NCHRP 1-37A model, traffic is considered in terms of axle load spectra. The full spectra for single, tandem, tridem, and quad axles is considered.

Part 2 of the design process is the structural/performance analysis. After the pavement structure or rehabilitation alternative is selected, a structural model that employs the input data prepared in Part 1 is used to estimate pavement response. The structural model for flexible pavement design is the JULEA linear elastic pavement model.

The pavement response computed in critical locations in the pavement structure is then used to estimate pavement performance. The performance is expressed by the evolution of major distresses in time. The distresses considered for new flexible pavement structures are: rutting, load associated cracking, temperature associated cracking and roughness of the longitudinal profile. Roughness is considered as a derivative distress; it is computed from the magnitude of rutting and cracking and not directly from pavement response data. The concept of reliability is introduced when the evolution of distresses are estimated. They are computed based on probabilistic reliability levels and typical standard deviations for each distress type.

The final version of the Guide does not allow automatic iterative adjustments of the design alternative if the performance criteria are not satisfactory. The user needs to modify the design pavement structural alternative and to rerun the software.

Part 3 of the process was planned to contain those activities required to evaluate the technically viable alternatives: an engineering analysis and life cycle cost analysis of the alternatives. Unfortunately, this part is not included in the final version of the NCHRP1-37A design software, even though in the initial stages of the development of the Guide, it was intended to do so. The user needs to successively select technical viable alternatives and to compute pavement performance for each alternative. The pavement performance data obtained from the runs on different alternatives need to be fed in a life cycle coast analysis. This will lead to the final selection of the optimum design solution.

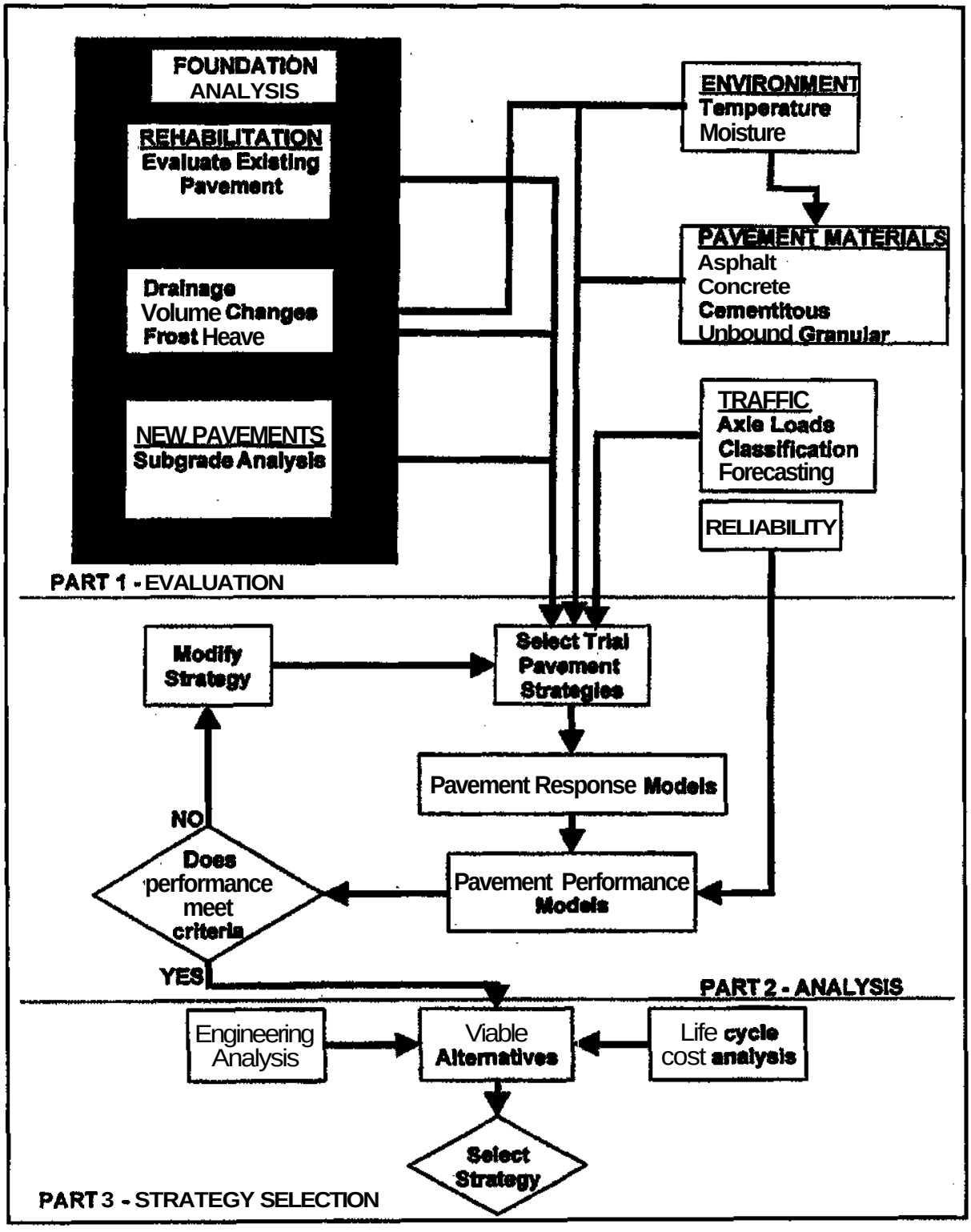


**Figure 2 Schematic of the Design Process**

**The Hierarchical Design Approach**

The NCHRP 1-37A design model uses a hierarchical design approach. Such an approach provides the designer with several levels of "design efficacy" that can be related to the class of highway under consideration or to the level of reliability of design desired. A chosen higher level of design output implies that the inputs also will be of a higher level. The hierarchical approach is employed with regard to traffic, materials, and environmental inputs and in some cases to the types of analyses used.

While there are many variations throughout the guide where as few as two levels or as many as four are available, the general approach is to provide for three levels. Within the three levels there also are variations, but generally the features of each level are [*3*]:

Level 1 - Level 1 is a "first class" or advanced design procedure and provides for the highest practically achievable level of reliability. It typically would be used for design in the heaviest traffic corridors or wherever there are dire safety or economic consequences of early failure. The design inputs also are of the highest practically achievable level and generally require site specific data collection and/or testing. Examples are dynamic modulus testing of asphalt concrete and site specific axle load spectra.

Level 2 - Level 2 is the standard design procedure expected to be used for routine design. Level 2 inputs typically would be user selected possibly from an agency database, would be derived from a less than optimum testing program, or would be estimated empirically. Examples would be dynamic modulus estimated from binder, aggregate, and mix properties or site-specific traffic volume and classification data used in conjunction with agency specific axle load spectra.

Level 3 - Level 3 typically is the lowest class of design and would be used where there are minimal consequences of early failure and on lower volume roads. Inputs typically would be user selected default values. Examples would be default dynamic modulus values for given mix classes or default axle load spectra for functional highway classes.

**Pavement Materials Characterization**

Materials characterization guidelines are provided so the designer can develop appropriate materials property inputs for use in the analysis portion of the design process. The materials parameters needed for the design process may be classified in one of three major groups:

- Pavement response model materials inputs
- Materials related pavement distress criteria
- Other materials properties.

Pavement response model material inputs related to the moduli and Poisson's ratio used to characterize layer behavior within the specific model. Bound materials such as AC, PCC, and high-strength stabilized bases generally display a linear or nearly linear stress-strain relationship. Unbound materials such as granular materials and fine-grained soils display stress dependent properties. Granular materials generally are "stress hardening" and show an increase in modulus with an increase in stress. Fine-grained soils generally are "stress softening" and display a modulus decrease with increased stress. Modulus-stress state relations have been developed for

granular materials and for fine-grained soils. In practice, assumed Poisson's ratio values are acceptable for routine mechanistic-empirical pavement design based on isotropic elastic structural analysis models. This is true because the parameter has well defined limits for specific materials types and because the stress, strain, and displacement outputs of the response model are not particularly sensitive to the parameter.

Materials parameters associated with pavement distress criteria normally are linked to some measure of material strength (shear strength, compressive strength, modulus of rupture, etc.). The "other" category of materials properties constitutes those associated with special properties required for the design solution. Examples of this category are the thermal expansion and contraction coefficients of both Portland cement concrete and asphalt mixtures.

**Classes of Materials**

In the NCHRP 1-37A design model, all flexible pavement materials have been classified in one of the following categories:

- Hot mix asphalt - dense graded (HMAC)
- Open graded asphalt treated materials (ATPB)
- Cold mix asphalt (CMA)
- Cementitious Stabilized Materials (CTB,CSB,CTPB )
- Non-Stabilized Granular Base/Subbase (AB,GAB,CA )
- Subgrade Soils
- Bedrock

*Levels of Materials Characterization*

In keeping with the hierarchical approach materials characterization is comprised of three levels with Level 1 indicative of a design approach philosophy of the highest practically achievable reliability and Levels 2 an 3 of successively lower reliability. The details of hierarchical characterization is given in the materials characterization section of the NCHRP 1-37A model [5]. However, a general tabulation of elastic modulus characterization methods is given in Table 1.

**Table 1 Characterization of Materials Modulus of Elasticity**

| Material | Level 1 | Level 2 | Level 3 |
|---|---|---|---|
| Asphalt Concrete | Measured Dynamic Modulus | Estimated Dynamic Modulus from binder viscosity and gradation data | Default Dynamic Modulus |
| Stabilized Materials | Measured Elastic Modulus | Estimated Elastic Modulus from chemical content and soil type | Default Elastic Modulus |
| Granular Materials | Measured Resilient Modulus | Estimated Resilient Modulus from gradation data | Default Resilient Modulus |
| Subgrades | Measured Resilient Modulus | Estimated Resilient Modulus from gradation and plasticity data or soil classification data | Default Resilient Modulus |

### *b2. Structural Response Models for Flexible Pavements*

Adequate structural modeling of flexible pavement structures is the heart of a mechanistic-based design procedure. Structural response models are used to compute critical stresses, strains, and displacements in flexible pavement systems due to both traffic loads and climatic factors (temperature and moisture). These responses are then utilized in damage model to accumulate damage, month by month, over the entire design period. The accumulated damage at any time is related to specific distresses such as fatigue cracking, which is then predicted using a field calibrated cracking model (the main empirical part of a mechanistic-empirical design procedure).

The structural models selected for use in the NCHRP 1-37A design model for flexible pavements include the multi-layer elastic system (JULEA code for linear elasticity). If the user opts to use the Level 1 hierarchical approach to characterize the non-linear moduli response of any unbound layer materials (bases, subbases and/or subgrades), then a 2-D finite element system (non-linear unbound materials) code (DSC2D) can be used. The structural response models require several inputs:

- Traffic loading
- Pavement cross-section
- Poisson's ratio each layer
- Elastic modulus each layer
- Thickness each layer
- Coefficient of thermal expansion (for AC)

Given these inputs the structural models produce stresses, strains, and displacements at critical locations in the pavement and subgrade layers.

This design procedure is the first to include the capability to accumulate damage on a monthly basis over the entire design period. This approach attempts to simulate how pavement damage occurs in nature, incrementally, load by load, over continuous time periods. By accumulating damage monthly, the design procedure becomes very versatile and comprehensive. This approach allows the use of elastic moduli within a given time period, such as a month, that are representative of that time increment. Thus, in the heat of summer, the dynamic modulus of AC is much lower than in the cold of winter. The resilient modulus of an unbound base course and of the fine-grained subgrade can vary with moisture content. This procedure also allows for the aging of paving materials. For example, AC materials age with time, increasing their stiffness. This is modeled so that the E of the AC is constantly increasing over time. It is believed that the added capabilities that incremental damage gives far outweigh its main disadvantage of computation time and the inclusion of aging models for paving materials.

### *b3. Performance Models for Flexible Pavements*

**Permanent Deformation Models**

The NCHRP 1-37A pavement design model [5] contains models for predicting permanent deformation in each pavement layer. The average vertical resilient strain in each layer/sublayer is computed for each analysis period of the entire design period with a linear elastic program for each axle load configuration. Rutting distress is predicted in absolute terms and not computed based on Miner's law; the incremental distress computed for each analysis period is directly accumulated over the entire target design life of the pavement.

The model used for unbound materials has the form:

$\delta_a(N) = \beta_1 * (So / \varepsilon_r) * \varepsilon_v * h * EXP[-(\rho/N)^{\beta}]$

where:

$\delta_a$ - Permanent deformation for the layer/sublayer
$\beta_1$ - Calibration factor for the unbound granular and subgrade materials
$\varepsilon_0$ , p and p - Material properties log p = -0.61 19 - 0.017638*$w_c$
$\varepsilon_r$ - resilient strain imposed in laboratory test to obtain the above listed material properties
$\varepsilon_v$ - Average vertical resilient strain in the layer/sublayer
h - thickness of the layer/sublayer
$w_c$ - water content in the layer/sublayer
N - Number of traffic repetitions

All parameters, except $\beta_1$, are computed as functions of the resilient modulus of the layer/sublayer and water content, estimated based on the ground water table depth. The final calibrated model parameters, derived from the permanent deformation data collected on 88 LTPP sections in 28 states were:

$\beta_{1GB}$ - 1.673 for unbound granular base and $\beta_{1SG}$ = 1.35 for unbound subgrade soil.

The relationship used in the NCHRP 1-37A mechanistic design guide to predict rutting of the asphalt mixes is based upon a field calibrated statistical analysis of repeated permanent deformation laboratory test results. The model is shown below:

$\varepsilon_p / \varepsilon_r = k_1 * 10^{-3.4488} * T^{1.5606} * N^{0.479244}$

$k_1 = (C_1 + C_2 * depth) * 0.328196^{depth}$

$C_1 = -0.1039 * h_{ac}^2 + 2.4868 * h_{ac} - 17.342$

$C_2 = 0.0172 * h_{ac}^2 - 1.7331 * h_{ac} + 27.428$

where:

$\varepsilon_0$ , P and p - Material properties
$\varepsilon_r$ - Resilient strain of the asphalt material as a function of mix properties, temperature and time rate of loading (in/in)
$\varepsilon_p$ - Accumulated plastic strain at N repetitions of load (in/in)
T - temperature (deg F)
N - Number of traffic repetitions
$h_{ac}$ - thickness of the layer/sublayer

The final calibrated model parameters were derived from the permanent deformation data collected on 88 LTPP sections in 28 states.

The models developed above were derived based on observed deformation of in-service pavement structures. The models are empirical. However, a desirable feature is that they include the effect of temperature and moisture content in the computation of permanent deformation directly through their effect on the resilient modulus of the foundation layers or dynamic modulus for the asphalt concrete layers.

**Load Associated Cracking Models**

Load associated cracking is one of the most common types of flexible pavement distresses. The repeated vehicle loads induce tensile stresses in the bound layers. Under repeated loadings, fatigue cracks initiate at locations where the largest tensile strains and stresses develop. The location of these critical points depends on many factors like the structural configuration of the pavement, the stiffness of the layers and the configuration of the wheel load (area of distribution, magnitude of stresses at the tire-pavement interface). After the cracking initiation at critical locations, the repeated traffic effect causes the cracks to propagate through the entire layer. These cracks allow water infiltration thereby reducing the overall performance of the pavement.

Most pavement structural models assume that cracks initiate at the bottom of the asphalt concrete surface layer and then propagate upward. These cracks are named bottom-up fatigue cracks. The NCHRP 1-37A Guide considers the alligator cracking as bottom-up fatigue cracking. In addition to the conventional bottom-up type fatigue cracking, top-down cracking is also taken into account. The NCHRP 1-37A Guide considers longitudinal cracks in the wheel path as top-down cracks. Even though there is no consensus on the cause for the formation of top-down cracking, there is extensive evidence for their existence.

The NCHRP 1-37A model adopted Miner's law to estimate fatigue damage:

$$D = \sum_{i=1}^{T} \frac{n_i}{N_i}$$

where,

$D$ = damage.
$T$ = total number of periods.
$n_i$ = actual traffic for period $i$.
$N_i$ = allowable repetitions to failure under conditions prevailing in period $i$.

The most commonly used model to predict the number of repetitions to fatigue cracking is a function of tensile strain and mix stiffness. The final relationship used for predicting the number of repetitions to fatigue cracking is the Asphalt Institute Model that is based on constant stress criterion. The final fatigue model used in the design guide obtained by numerical optimization and other modes of comparison is as below:

$$N_f = 0.00432 * k_1' * C (1/\varepsilon_t)^{3.9492} (1/E)^{1.281}$$

where:

$C = 10^M$ and $M = 4.84*[V_b / (V_a+V_b) - 0.69]$
$V_b$ = effective binder volumetric content (%).
$V_a$ = air voids (%).

The parameter $k_1^{'}$ was introduced to account for different asphalt layer thicknesses and is given by below for bottom-up cracking.

$$k'_1 = \frac{1}{0.000398 + \frac{0.003602}{1 + e^{(11.02-3.49*h_{ac})}}}$$

For top-down cracking, it is given by:

$$k_1^{'} = \frac{1}{0.01 + (12.00/1 + e^{(15.676-2.8186*h_{ac})})}$$

Finally, the transfer function to estimate fatigue cracking from fatigue damage is expressed as in the equations below for bottom-up and top-down cracking respectively.

*Bottom-up cracking*

$$F.C. = \left( \frac{6000}{1 + e^{(C_1*C'_1 + C_2*C'_2*\log 10(D*100))}} \right) * \left( \frac{1}{60} \right)$$

Where:

F.C=bottom-up fatigue cracking, percent lane area
D= bottom-up fatigue damage
Cl = 1.0
C2 = 1.0
C'1= -2 * C'2
$C'_2$ = -2.40874-39.748*$(1+h_{ac})^{-2.856}$

*Top-down cracking*

$$F.C. = \left( \frac{1000}{1 + e^{(7-3.5*\log 10(D*100))}} \right) * 10.56$$

where,

FC= top-down fatigue cracking, ft/mile
D= top-down fatigue damage

The fatigue cracking model for asphalt concrete was calibrated based on data from 82 LTPP sections located in 24 states, using 441 observations for alligator cracking and 408 data points for longitudinal cracking. The bottom-up cracking is calculated as a percentage of lane area while the longitudinal cracking is expressed in terms of linear feet per mile of pavement.

An important observation made during the calibration process was that for all levels of asphalt thickness the alligator cracking increases with decreasing subgrade modulus. It was also

observed that the impact of subgrade support upon alligator cracking is directly dependent on the thickness of HMA layer, and that the greatest potential for damage is observed for asphalt layers with thickness in the range of 3 to 5 inches.

The fatigue damage reduces below the maximum cracking level in the range of 3 to 5 inches because at the bottom of very thin HMA layers little or no tensile stresses or strains develop. Pavements with thin HMA layers exhibit rutting failure in the foundation layers before exhibiting fatigue cracking in the asphalt concrete layers.

## OBJECTIVES

The objectives of this research are:

- to validate and calibrate the dynamic resilient modulus model used in NCHRP 1-37A for asphalt concrete mixes and to compare it with the field-measured modulus, for two mixes in each of the four Mid-West States;
- to validate the relationship used in NCHRP 1-37A between the dynamic modulus and pavement response;
- to validate the relationship used in NCHRP 1-37A between pavement response (strains) and pavement performance;
- to compare the performance of coarse and fine Superpave mixes;
- to validate and calibrate the Asphalt Pavement Analyzer (APA) as a screening tool for estimating rutting performance of Superpave asphalt mixes.

To achieve these objectives, sixteen pavements will be constructed for this experiment and will be built in eight pairs. Four pairs will be 'fatigue cracking' experiments and will aim to verify the fatigue cracking properties of asphalt concrete. The remaining four pairs will be 'rutting' experiments and will aim to determine the rutting life of asphalt concrete pavements. In total, eight mixes will be used, two for each state. One 'fatigue cracking' and one 'rutting' pavement will be built for each mix.

## BENEFITS

The results of this research will provide valuable support for the calibration and implementation of the NCHRP 1-37A design model and will provide a database of pavement response and performance information valuable for verification of any mechanistic-empirical pavement design method. The results will also establish the fatigue and rutting behavior of fine and coarse Superpave mixes and will provide a screening tool for rut-susceptible mixes.

Data collected during the experiment will be analyzed and the analysis results will be made available to the four state agencies involved in this project. The findings of this experiment will be summarized in scientific journal publications and presentations delivered at scientific conferences and meetings with specialists and practitioners in the field of highway engineering.

## V WORK PLAN

The time line of the work plan for this research project is presented in Table 2. Individual tasks are discussed below.

**TABLE 2 Time line for the work plan**

| TASK | Schedule |
|---|---|
| 1 | April 1, 2005 - December 31, 2005 |
| 2 | May 1, 2005 - December 1, 2007 |
| 3 | June 1, 2005 - January 31, 2008 |
| 4 | June 1, 2005 - January 31, 2008 |
| 5 | July 1, 2005 - February 31, 2008 |
| 6 | January 1, 2008 - March 31, 2008 |

### Task 1: Experiment Preparation

The literature related to the NCHRP 1-37A design guide and the models it contains will be reviewed. Other relevant APT work for the validation of pavement response and performance models will also be reviewed.

A major component of the experimental design is the selection and design of the HMA Superpave mixes. Two mixes will be tested for each state. The mixes can be produced by Shilling Construction Co. as follows:

*Option 1 :* with the locally available aggregates and designed according to each State's specifications, or

*Option 2:* with aggregates hauled in from each State at its expense. Approximately 25 tons of each aggregate will be required to produce one mix.

The two options will be discussed with the Bituminous Materials Engineers and the TAC panel in the four states, to find the optimum ways of producing representative mixes for the four states. If necessary, samples of Kansas aggregates and binder to be used by Shilling Construction Co. will be provided to the Bituminous Materials Engineers in four states to perform mix designs. If the states decide to use their own aggregates, the Engineers will be responsible for collecting local aggregate samples.

To optimize the experiment preparation and development, it is proposed that the first four pavements, corresponding to two mixes, will be constructed with Kansas Superpave mixes. This way, the design of the mixes for the other three states will be done when the Kansas mixes are being tested.

At this stage, the instrumentation for pavement monitoring will be designed. The work will include selection and purchase of appropriate sensors, as well as drafting of the pavement monitoring plan.

The project preparation also will include the design and construction of the temperature control chamber, which will encase the ATL machine. The chamber will provide the opportunity

to control temperatures at the surface of the asphalt concrete layer. For this experiment, it is proposed that the testing be performed at constant, controlled pavement surface temperature: 35°C for the rutting experiments and 20°C for the fatigue cracking experiments.

## Task 2: Construction of the Pavement Sections

This task will include construction of sixteen test sections at CISL, corresponding to eight Superpave HMA mixes, two mixes for each state. Two pavement sections will be constructed for each mix: one for the rutting experiment and one for the fatigue cracking experiment. In all rutting sections, the asphalt concrete surface layer will be seven inches thick. In all fatigue cracking sections, the asphalt concrete surface layer will be 3.5 inches thick. All pavement sections will have the same six inch Kansas AB-3 aggregate base placed on top of the same subgrade soil. It is proposed that a clayey A-7-6 local soil be used for the subgrade layer.

Before construction, the pavement sections tested in Experiment No. 13 will be removed. New soil will be placed in the pits and compacted. The moisture of the new soil and of the AB-3 aggregate base will be controlled to be close to the optimum values. Density measurements will be performed with the nuclear density gage in the compacted soil subgrade and aggregate base. Stiffness measurements will be performed at the top of the subgrade and base layers with the GeoGage and the Prima 100 Light Weight FWD.

The hot-mix asphalt concrete will be produced, placed, and compacted by Shilling Construction Co. of Manhattan. The HMA mix will be placed and compacted to the desired density (93% or above of theoretical maximum density) and thickness (seven inches for the rutting experiments, placed in two lifts and 3.5 inches for the fatigue experiments).

If any of the states decides to use their local aggregates in the construction of their mixes, the states will be responsible for providing, at their own cost, at least 25 tons of each aggregate to Shilling Construction Co. The company requested this amount as necessary to produce sufficient and uniform mix.

The instrumentation for monitoring pavement response will be installed in the lanes during construction. The proposed instrumentation consists of pressure cells, strain gages, single layer Deflectometer, thermocouples and soil moisture gages. A detailed description of the type and location of each sensor is given in the pavement monitoring section. By the time the testing is performed, the capability for controlling the temperature at the surface of the pavement will exist.

Laboratory tests will be performed on material samples taken from the construction site as well as on the laboratory-prepared specimens. The material characteristics to be measured on the samples include:

- *Asphalt Binder.*
  - Dynamic Shear Rheometer G* and sin(S)
- *Asphalt Concrete:*
  - Density
  - Indirect Tensile Resilient Modulus at three temperatures and five frequencies
  - Dynamic resilient modulus at five temperatures and five frequencies,
  - Static and dynamic creep at the APT test temperature (35°C is proposed )

- Third point bending fatigue at the APT test temperature (10°C is proposed )
- Rutting with the Hamburg Wheel Rut Tester
- Rutting with the APA Rut Tester (this will be done outside KSU)

- *Aggregates used in the HMA mixes:*
  - Gradation
  - Angularity
  - Particle Shape
  - Los Angeles Abrasion
- *AB-3 Aggregate Base:*
  - Gradation
  - Resilient Modulus
- *Subgrade Soil:*
  - Plasticity
  - Swell
  - Gradation
  - Resilient Modulus
  - Permanent deformation under repeated triaxial test

These material characteristics will be determined at the Bituminous Materials Laboratory and the Aggregate Characterization Laboratory at the KSU Civil Engineering Department.

### Task 3: Full-Scale Accelerated Pavement Testing

After construction, the lanes will be tested under the full-scale truck loading provided by the ATL loading frame. The proposed temperature control chamber will allow the temperature to be controlled at a desired level. Bi-directional trafficking is recommended for the "fatigue cracking" pavements and uni-directional for the "rutting" pavements sections.

It is proposed that a 115 kN (26,000 lb) single axle load and a tire inflation pressure of 690 kPa (100 psi) are to be used in this experiment. The axle load and tire pressure will be kept the same during the entire duration of the experiment. The lateral position of the ATL machine will be changed during testing such that it will follow a normal distribution, truncated at the 95$^{th}$ percentile. Loading will be applied until at least one of the following distress levels is reached:

- 12.5 mm (0.5 in.) rut depth at the pavement surface;
- 25% of each lane area is cracked (equivalent to 50% of the trafficked are cracked).

Full scale APT testing and pavement construction will be coordinated to optimize the development of the project, to reduce the time and the effort to achieve the project objectives.

### Task 4: Pavement Monitoring

The condition of the pavement as well as stresses and strains in the tested pavement structures will be monitored during the entire duration of the experiment. Longitudinal and transverse profiles will be measured on the test lanes at every 100,000 cycles of the ATL

machine. Three transverse profiles along the each lane will be recorded using the transverse rut measuring device used in the previous CISL experiments. The rut depth values derived from the profiles will be computed. One longitudinal profile will be recorded for each lane. After surface cracks are first observed, crack mapping will be performed simultaneously with the profile measurements. The cracking extent and severity will be determined from the mapped data. The calculation of the percentage of area with fatigue cracking will be done for the grid with the size of the squared openings of 6 inches.

The Weight Drop NDT device will be used to perform surface deflection tests at 0, 5,000, 25,000, 50,000 and 100,000 repetitions and then at every 200,000 cycles of the ATL loading. The deflection data will be used to backcalculate the elastic layer moduli to determine the degradation of the materials with the accumulated traffic.

Strain and stress measurements under the passing axle will be performed at 0, 5,000, 25,000, 50,000 and 100,000 repetitions and then at every 100,000 cycles of the CISL axle. On the newly constructed pavements, strain-stress measurements at two other temperatures than the testing temperature will be attempted. The proposed locations of the strain gages and pressure cells are presented in Figure 2. The same configuration (2 transverse strain gauges, 2 longitudinal strain gauges, 2 pressure cells, 3 single layer deflectometers, 4 temperature sensors and 2 TDR gauges) for the instrumentation will be used for all lanes. Moisture and temperature data will be monitored periodically to ensure that the subgrade is at the optimum moisture content.

Falling Weight Deflectometer tests will be conducted by the KDOT crew. The tests will be scheduled in consultation with the KSU-CISL research team. The FWD tests will be performed on the four test lanes as follows:

- After construction of the lanes or right before testing is started
- After 5,000 loading cycles
- After 100,000 loading cycles
- After loading is completed.

The FWD test sequence covers a period of approximately six months. The FWD tests will be performed at three locations per lane, with drop configurations selected by the KDOT crew and the KSU-CISL research team. The drop configuration used in Experiment 11 will be used. The KDOT crew will provide the deflection data to the KSU-CISL research team, who will be responsible for data processing and moduli backcalculation.

The forensic evaluation of the tested lanes will be performed in order to investigate the failure mode and the causes of failure. After failure, one trench will be cut in each test lane down to the level of the subgrade soil. The transverse profile at the top of the base layer and on top of the surface layer will be recorded to determine the contribution of the asphalt surface layer to the surface rutting.

### Task 5: Analysis of Results

The data collected during pavement monitoring will be analyzed to determine the response of the pavements to the applied loading, the evolution of distresses, and changes in material properties. Runs of the NCHRP 1-37A software will be performed for all pavements tested, using the

laboratory-measured material properties, to estimate pavement response and the rutting and cracking performance and, to compare them with those measured on the test pavements.
The results of the APT and laboratory tests will also investigated using statistical analysis:

- the comparative performance of the mixes from the same state
- the relationship between the APT rutting performance of the eight mixes and the rutting performance measured with the Hamburg and the APA Rut Testers.
- the relationship between the APT fatigue cracking performance of the eight mixes and the laboratory-measured fatigue performance.

Task 7: Report Writing and Results

A final report containing a detailed description of the construction, test methodology, and results will be delivered at the end of the experiment. The report will contain all information related to the construction of the test lanes, results from the laboratory and field tests of the materials, pavement condition and monitoring data, data analysis methods, summary of the test results, conclusions and recommendations. The research team will also deliver a detailed presentation on the experiment at the end of this project.

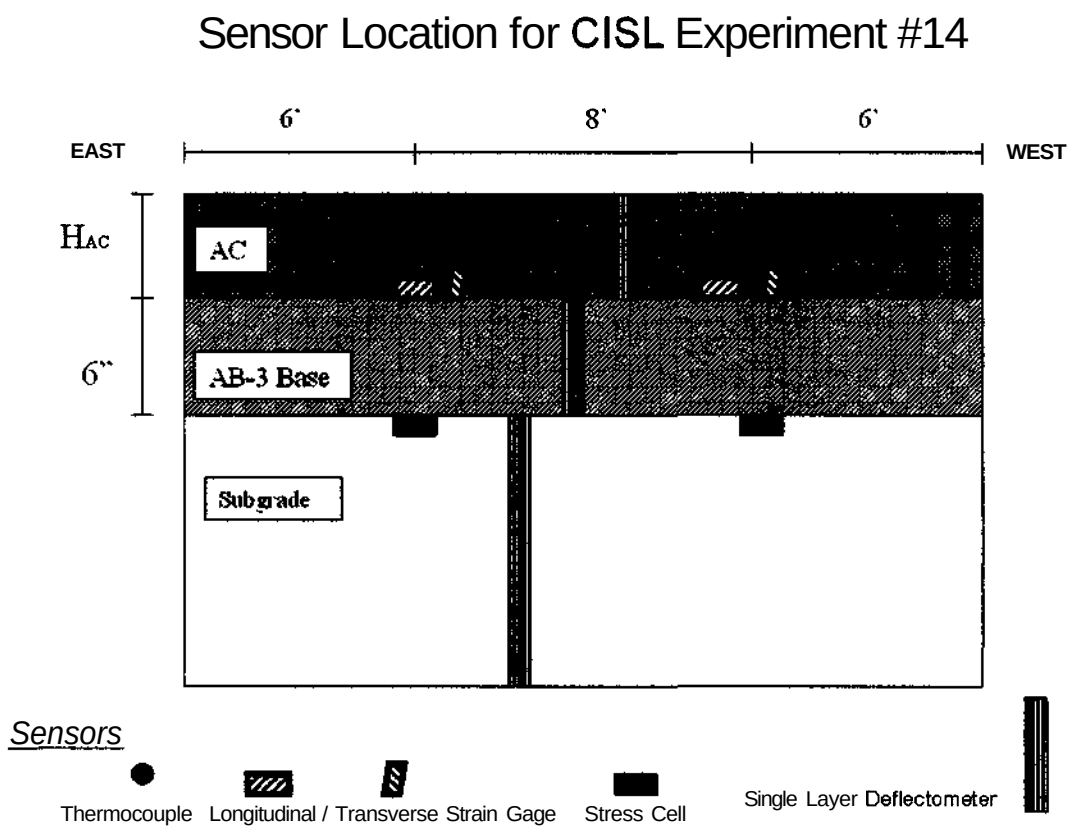


**Figure 2. Schematic Diagram of the Proposed Pavement Response Instrumentation**

# VI. PROPOSED BUDGET

For the Period 04/01/05 to 3/31/08

| A. SALARIES, WAGES & FRINGE BENEFITS | KDOT | KSU |
|---|---|---|
| **1 Principal Investigator: Stefan Romanoschi** | | |
| 0.2 time, 1.5 months academic year '04-'05 | 1,051 | 1,051 |
| 1.0 time, 2 month summer 2005 | 14,299 | |
| 0.2 time, 9 months academic year '05-'06 | 7,290 | 7,290 |
| 1.0 time, 2 month summer 2006 | 14,871 | |
| 0.2 time, 9 months academic year '06-'07 | 7,581 | 7,581 |
| 1.0 time, 2 month summer 2007 | 15,466 | |
| 0.2 time, 7.5 months academic year '07-'08 | 6,702 | 6,702 |
| **2 Co-Principal Investigator: Mustaque Hossain** | | |
| 1.0 time, 1 month summer 2005 | 8,910 | |
| 0.2 time, 3 months academic year '05-'06 | 2,726 | 2,726 |
| 1.0 time, 1 month summer 2006 | 9,267 | |
| 0.2 time, 3 months academic year '06-'07 | 2,835 | 2,835 |
| 1.0 time, 1 month summer 2007 | 9,638 | |
| 0.2 time, 1.5 months academic year '06-'07 | 1,474 | 1,474 |
| **3 Research Technologist (Paul Lewis)** | | |
| 1.0 time, 3 months year '04 | 12,250 | |
| 1.0 time, 12 months year '05 | 50,960 | |
| 1.0 time, 12 months year '06 | 52,998 | |
| 1.0 time, 9 months year '07 | 41,339 | |
| **4 Graduate Research Assistant** | | |
| 1 @ 0.5 time, 3 months calendar year (PhD) | 4,725 | |
| 1 @ 0.5 time, 12 months calendar year (PhD) | 18,252 | |
| 1 @ 0.5 time, 12 months calendar year (PhD) | 18,982 | |
| 1 @ 0.5 time, 9 months calendar year (PhD) | 14,426 | |
| **5 Undergraduate Students** | **16,000** | |
| **6 Fringe Benefits** | | |
| 32.5% of A1- A3, 5% of A4 and 1.4% of A5 | 87,432 | 9,639 |
| **Subtotal Salaries, Wages and Fringe Benefits** | 419,474 | 39,298 |
| **B. EQUIPMENT** | | |
| Instrumentation | 9,000 | |
| **C. MATERIALS AND SUPPLIES** | 19,500 | |
| **D. TRAVEL - DOMESTIC** | 2,000 | |
| **E. OTHER DIRECT COSTS** | | |
| 1 Fees for ATL equipment usage | 200,000 | |
| 2 Service for soil and pavement placing and removal | 45,000 | |
| 3 In-state Tuition - Graduate Student (Full) | | |
| 3 hrs. Summer; 9 hrs. Fall & Spring | 9,500 | |
| 4 Telecommunication, Duplication | 1,218 | |
| **Subtotal Other Direct Costs** | 255,718 | |
| **Total Direct Costs** | 705,692 | 39,298 |
| **F. FACILITIES AND ADMINISTRATIVE COSTS** | | |
| 26 % of MTDC | 178,670 | |
| 46% of MTDC | | 18,077 |
| 46 % of MTDC less sponsor share | | 137,438 |
| **TOTAL PROJECT COST** | **884,362** | **194,813** |

### Base Funding

The base funding required to operate the facility is an estimated $17,500 per month. This amount provides staff and student salary support that are on going. If this project is extended or there is a delay in starting a subsequent project, this amount may be used to estimate the associated fixed costs.

## VII STAFF AND FACILITIES AVAILABLE

### Staff

The principal investigator for this project will be Dr. Stefan Romanoschi. Co-Principal investigator will be Dr. Mustaque Hossain. Mr. Paul Lewis is the Research Technologist at the ATL. He will be fully supported using funds from the proposed project, during the estimated duration of pavement construction and testing. Also, undergraduate engineering students at KSU will be employed on an hourly basis. Graduate students will help do laboratory tests, collect and analyze test data, and help in the implementation and calibration of the control and sensing devices.

Dr. Romanoschi is an Assistant Professor at the Department of Civil Engineering at KSU. His expertise is related to pavement condition monitoring, pavement instrumentation and full-scale accelerated pavement testing, pavement structure modeling and design, Finite Element Analysis of pavement structures, and applied statistics in civil engineering. Dr. Romanoschi is the author and co-author of several publications related to field and laboratory testing of soil and highway materials and full-scale accelerated pavement tests.

Dr. Hossain is Professor of Civil Engineer at KSU. Dr. Hossain is author and co-author of many publications related to field and laboratory testing of soil and highway materials, and full-scale accelerated pavement tests and, a Principal and Co-Principal Investigator in many research projects in the ATL. Dr. Hossain is also a member of TRB Committee AFD40: Full Scale Accelerated Pavement Testing.

Mr. Paul Lewis is the full-time research technologist hired by the KSU Civil Engineering Department to work at the ATL on pavement related testing experiments. He has been employed at the ATL for over seven years and has demonstrated excellent abilities to perform the different tasks required to conduct the work at the facility. Prior to that, he was affiliated with KSU where he worked for several years at the University Power Plant, Division of Facilities. As in the past he is totally supported by the Accelerated Testing Pooled Funds Program, and his time is entirely dedicated to the development of the ATL pavement testing experiments.

### Facilities

The experimental investigation, which constitutes the majority of the work on this project, will be conducted at the Civil Infrastructure System Laboratory at KSU. The laboratory is located in the Manhattan industrial park in the east part of the city. The facility includes the Kansas Accelerated Testing Laboratory (ATL) where the tests will be performed, the Falling Weight Deflectometer (FWD) calibration facility, and a large frame for concrete beam testing.

# CERTIFICATE OF THE KANSAS STATE UNIVERSITY

I hereby certify that I am the Assistant Vice Provost for Research and duly authorized representative of The Kansas State University and that neither I nor the above agency I here represent has:

(a) employed or retained for the payment of a commission, percentage, brokerage, contingent fee, or other consideration, any person (other than a bona fide employee working solely for me or the Kansas State University) to solicit or secure this Agreement,

(b) agreed, as an express or implied condition for obtaining this Agreement, to employ or retain the services of any firm or person in connection with carrying out the Agreement, or

(c) paid, or agreed to pay, to any firm, organization of persons (other than a bona fide employee working solely for me or the Kansas State University) any fee, contribution, donation, or consideration of any kind, for, or in connection with, procuring or carrying out the Agreement;

except as here expressly stated (if any):

I acknowledge that this certificate is to be furnished to the Secretary of Transportation of the State of Kansas in connection with this Agreement and is subject to applicable State and Federal laws, both criminal and civil.

12-10-04
(DATE)

Paul R. Lowe
PAUL R. LOWE
Assistant Vice Provost for Research
of the Kansas State University

CERTIFICATION OF THE SECRETARY OF TRANSPORTATION

I hereby certify that I am the Secretary of Transportation of the State of Kansas and that The Kansas State University or their representative has not been required, directly or indirectly as an express or implied condition in connection with obtaining or carrying out this Agreement to:

(a) employ or retain, or agree to employee or retain, any firm or person, or,

(b) pay, or agree to pay, to any firm, person, or organization, any fee, contribution, donation, or consideration of any kind;

except as here expressly stated (if any):

I acknowledge that this certificate is to be furnished to the above referenced firm in connection with this Agreement, and is subject to applicable State and Federal laws, both criminal and civil.

12/17/04
(DATE)

Warren L. Sick

DEBRA L. MILLER
Secretary of Transportation
By: Warren L. Sick
Assistant Secretary and
State Transportation Engineer

# KANSAS DEPARTMENT OF TRANSPORTATION

Special Attachment
To Contracts or Agreements Entered Into
By the Secretary of Transportation of the State of Kansas

NOTE: Whenever this Special Attachment conflicts with provisions of the Document to which it is attached, this Special Attachment shall govern.

THE CIVIL RIGHTS ACT OF 1964, and any amendments thereto,
REHABILITATION ACT OF 1973, and any amendments thereto,
AMERICANS WITH DISABILITIES ACT OF 1990, and any amendments thereto,
AGE DISCRIMINATION ACT OF 1975, and any amendments thereto,
EXECUTIVE ORDER 12898, FEDERAL ACTIONS TO ADDRESS ENVIRONMENTAL JUSTICE IN MINORITY POPULATIONS AND LOW INCOME POPULATIONS (1994), and any amendments thereto,
49 C.F.R. Part 26.1 (DBE Program), and any amendments thereto

## NOTIFICATION

The Secretary of Transportation for the State of Kansas, in accordance with the provisions of Title VI and Title VII of the Civil Rights Act of 1964 (78 Stat. 252), §504 of the Rehabilitation Act of 1973 (87 Stat. 3555) and the Americans with Disabilities Act of 1990 (42 USC 12101), the Age Discrimination Act of 1975 (42 USC 6101), the Regulations of the U. S. Department of Transportation (49 C.F.R., Part 21, 23, and 27), issued pursuant to such ACT, Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations (1994), and the DBE Program (49 C.F.R., Part 26.1), hereby notifies all contracting parties that, the contracting parties will affirmatively insure that this contract will be implemented without discrimination on the grounds of race, religion, color, gender, age, disability, national origin, or minority populations and low income populations as more specifically set out in the following seven "Nondiscrimination Clauses".

## CLARIFICATION

Where the term "consultant" appears in the following seven "Nondiscrimination Clauses", the term "consultant" is understood to include all parties to contracts or agreements with the Secretary of Transportation of the State of Kansas.

## Nondiscrimination Clauses

During the performance of this contract, the consultant, or the consultant's assignees and successors in interest (hereinafter referred to as the "Consultant"), agrees as follows:

(1) Compliance with Regulations: The consultant will comply with the Regulations of the U. S. Department of Transportation relative to nondiscrimination in federally-assisted programs of the U.S. Department of Transportation (Title 49, Code of Federal Regulations, Parts 21, 23 and 27,

hereinafter referred to as the Regulations), which are herein incorporated by reference and made a part of this contract.

(2) Nondiscrimination: The consultant, with regard to the work performed by the consultant after award and prior to the completion of the contract work, will not discriminate on the grounds of race, religion, color, gender, age, disability, national origin or minority populations and low income populations in the selection and retention of subcontractors, including procurements of materials and leases of equipment. The consultant will not participate either directly or indirectly in the discrimination prohibited by Section 21.5 of the Regulations, including employment practices when the contract covers a program set forth in Appendix B of the Regulations.

(3) Solicitations for Subcontractors, Including Procurements of Material and Equipment: In all solicitations, either competitive bidding or negotiation made by the consultant for work to be performed under a subcontract including procurements of materials and equipment, each potential subcontractor or supplier shall be notified by the consultant of the consultant's obligation under this contract and the Regulations relative to nondiscrimination on the grounds of race, religion, color, gender, age, disability, national origin or minority populations and low income populations.

(4) Information and Reports: The consultant will provide all information and reports required by the Regulations, or orders and instructions issued pursuant thereto, and the Secretary of the Transportation of the State of Kansas will be permitted access to the consultant's books, records, accounts, other sources of information, and facilities as may be determined by the Secretary of Transportation of the State of Kansas to be pertinent to ascertain compliance with such Regulations, orders and instructions. Where any information required of a consultant is in the exclusive possession of another who fails or refuses to furnish this information, the consultant shall so certify to the Secretary of Transportation of the State of Kansas and shall set forth what efforts it has made to obtain the information.

(5) Employment: The consultant will not discriminate against any employee or applicant for employment because of race, religion, color, gender, age, disability, or national origin.

(6) Sanctions for Noncompliance: In the event of the consultant's noncompliance with the nondiscrimination provisions of this contract, the Secretary of Transportation of the State of Kansas shall impose such contract sanctions as the Secretary of Transportation of the State of Kansas may determine to be appropriate, including, but not limited to,

(a) withholding of payments to the consultant under the contract until the contractor complies, and/or

(b) cancellation, termination or suspension of the contract, in whole or in part.

(7) Disadvantaged Business Obligation

(a) Disadvantaged Businesses as defined in the Regulations, shall have a level playing field to compete fairly for contracts financed in whole or in part with Federal funds under this contract.

(b) All necessary and reasonable steps shall be taken in accordance with the Regulations to ensure that Disadvantaged Businesses have equal opportunity to compete for and perform contracts. No person(s) shall be discriminated against on the basis of race, color, gender, or national origin in the award and performance of federally-assisted contracts.

(c) The contractor, sub recipient or subcontractor shall not discriminate on the basis of race, color, national origin, or sex in the performance of this contract. The contractor shall carry out applicable requirements of 49 CFR Part 26 in the award and administration of Federally-assisted contracts. Failure by the contractor to carry out these requirements is a material breach of this contract, which may result in the termination of this contract or such other remedy, as the recipient deems appropriate.

(8) Executive Order 12898

(a) To the extent permitted by existing law, and whenever practical and appropriate, all necessary and reasonable steps shall be taken in accordance with Executive Order 12898 to collect, maintain, and analyze information on the race, color, national origin and income level of persons affected by programs, policies and activities of the Secretary of Transportation of the state of Kansas and use such information in complying with this Order.

(9) Incorporation of Provisions: The consultant will include the provisions of paragraphs (1) through (8) in every subcontract, including procurements of materials and equipment, unless exempt by the Regulations, order, or instructions issued pursuant thereto. The consultant will take such action with respect to any subcontract or procurement as the Secretary of Transportation of the State of Kansas may direct as a means of enforcing such provisions including sanctions for noncompliance: PROVIDED, however, that, in the event a consultant becomes involved in, or is threatened with, litigation with a subcontractor or supplier as a result of such direction, the consultant may request the State to enter into such litigation to protect the interests of the State.

# CERTIFICATION BY PROSPECTIVE PARTICIPANTS AS TO CURRENT HISTORY REGARDING DEBARMENT, ELIGIBILITY, INDICTMENTS, CONVICTIONS, OR CIVIL JUDGMENTS

PAUL R. LOWE, Assistant Vice Provost for Research, Kansas State University, being duly sworn (or under penalty of perjury under the laws of the United States), certifies that, except as noted below, the Kansas State University or any person associated therewith in the capacity of director, officer, principal investigator, project director, manager, auditor, or any position involving the administration of federal funds:

a) is not currently under suspension, debarment, voluntary exclusion, or determination of ineligibility by any federal agency;

b) has not been suspended, debarred, voluntarily excluded or determined ineligible by any federal agency within the past 3 years;

c) does not have a proposed debarment pending; and,

d) has not been indicted, convicted or has a civil judgment rendered against (it) by a court of competent jurisdiction in any matter involving fraud or official misconduct within the past 3 years.

Exceptions: _____

_____

Providing false information may result in criminal prosecution or administrative sanctions.

12-10-04
Date

Paul R. Lowe
Assistant Vice Provost for Research
Kansas State University

This project or contract is being funded in part by federal funds, and therefore the following certification applies:

CERTIFICATION FOR FEDERAL AID CONTRACTS

The following provision shall apply to all applicants for or recipients of federal funding on federal contracts, grants, loans, or cooperative agreements in excess of $100,000, pursuant to 31 U.S.C. Section 1352: Sect. 319 of P.L. 101.121.

Each applicant for or recipient of any amount of federal funding shall signify in writing below the amount of federal funding applied for or received by this contract, loan, grant, or cooperative agreement, if known.

The prospective participant certifies, by signing below and submitting this bid, proposal, grant, loan, cooperative agreement, or contract, to the best of his or her knowledge and belief, that:

1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any federal agency, a member of Congress, an officer or employee of Congress, or an employee of a member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any Federal agency, a member of Congress, an officer or employee of Congress, or an employee of a member of Congress in connection with this Federal contract, grant, load, or cooperative agreement, the undersigned shall complete Standard Form LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions. (A copy of Standard Form LLL is attached.)

A disclosure form must also be submitted at the end of each calendar year quarter in which there occurs any event which requires disclosure or that materially affects the accuracy of the information contained in any previously filed disclosure form. The original of the disclosure form shall be submitted to:_____, the KDOT Project Manager for this project or contract.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Signature of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

The prospective participant also agrees by signing below that he or she shall require that the language of this certification be included in all lower tier subcontracts which exceed $100,000, and that such subrecipients shall certify and disclose accordingly. The originals of all disclosure forms submitted to the prime contractor by lower tiers shall be sent to the KDOT Project Manager named above.

Paul R. Lowe

Signature Paul R. Lowe
Assistant Vice Provost for Research
Kansas State University

12-10-04

Date

Title

Kansas State University

Agency

Amount of Federal Funds (if known)

Project or Contract No.

State of Kansas
Department of Administration
DA-146a (Rev. 1-01)

Special Attachment No. 6

# CONTRACTUAL PROVISIONS ATTACHMENT

Important: This form contains mandatory contract provisions and must be attached to or incorporated in all copies of any contractual agreement. If it is attached to the vendor/contractor's standard contract form, then that form must be altered to contain the following provision:

"The Provisions found in Contractual Provisions Attachment (Form DA-146a, Rev. 1-01), which is attached hereto, are hereby incorporated in this contract and made a part thereof."

The parties agree that the following provisions are hereby incorporated into the contract to which it is attached and made a part thereof, said contract being the _____ day of _____, 20 04 .

1. **Terms Herein Controlling Provisions:** It is expressly agreed that the terms of each and every provision in this attachment shall prevail and control over the terms of any other conflicting provision in any other document relating to and a part of the contract in which this attachment is incorporated.

2. **Agreement With Kansas Law:** All contractual agreements shall be subject to, governed by, and construed according to the laws of the State of Kansas.

3. **Termination Due To Lack Of Funding Appropriation:** If, in the judgment of the Director of Accounts and Reports, Department of Administration, sufficient funds are not appropriated to continue the function performed in this agreement and for the payment of the charges hereunder, State may terminate this agreement at the end of its current fiscal year. State agrees to give written notice of termination to contractor at least 30 days prior to the end of its current fiscal year, and shall give such notice for a greater period prior to the end of such fiscal year as may be provided in this contract, except that such notice shall not be required prior to 90 days before the end of such fiscal year. Contractor shall have the right, at the end of such fiscal year, to take possession of any equipment provided State under the contract. State will pay to the contractor all regular contractual payments incurred through the end of such fiscal year, plus contractual charges incidental to the return of any such equipment. Upon termination of the agreement by State, title to any such equipment shall revert to contractor at the end of State's current fiscal year. The termination of the contract pursuant to this paragraph shall not cause any penalty to be charged to the agency or the contractor.

4. **Disclaimer Of Liability**: Neither the State of Kansas nor any agency thereof shall hold harmless or indemnify any contractor beyond that liability incurred under the Kansas Tort Claims Act (K.S.A. 75-6101 et seq.).

5. **Anti-Discrimination Clause:** The contractor agrees: (a) to comply with the Kansas Act Against Discrimination (K.S.A. 44-1001 et sea.) and the Kansas Age Discrimination in Employment Act (K.S.A. 44-1111 et seq.) and the applicable provisions of the Americans With Disabilities Act (42 U.S.C. 12101 et sea.) (ADA) and to not discriminate against any person because of race, religion, color, sex, disability, national origin or ancestry, or age in the admission or access to, or treatment or employment in, its programs or activities; (b) to include in all solicitations or advertisements for employees, the phrase "equal opportunity employer"; (c) to comply with the reporting requirements set out at K.S.A. 44-1031 and K.S.A. 44-1116; (d) to include those provisions in every subcontract or purchase order so that they are binding upon such subcontractor or vendor; (e) that a failure to comply with the reporting requirements of (c) above or if the contractor is found guilty of any violation of such acts by the Kansas Human Rights Commission, such violation shall constitute a breach of contract and the contract may be cancelled, terminated or suspended, in whole or in part, by the contracting state agency or the Kansas Department of Administration; (f) if it is determined that the contractor has violated applicable provisions of ADA, such violation shall constitute a breach of contract and the contract may be cancelled, terminated or suspended, in whole or in part, by the contracting state agency or the Kansas Department of Administration.

   Parties to this contract understand that the provisions of this paragraph number 5 (with the exception of those provisions relating to the ADA) are not applicable to a contractor who employs fewer than four employees during the term of such contract or whose contracts with the contracting state agency cumulatively total $5,000 or less during the fiscal year of such agency.

6. **Acceptance Of Contract:** This contract shall not be considered accepted, approved or otherwise effective until the statutorily required approvals and certifications have been given.

7. **Arbitration. Damages. Warranties:** Notwithstanding any language to the contrary, no interpretation shall be allowed to find the State or any agency thereof has agreed to binding arbitration, or the payment of damages or penalties upon the occurrence of a contingency. Further, the State of Kansas shall not agree to pay attorney fees and late payment charges beyond those available under the Kansas Prompt Payment Act (K.S.A. 75-6403), and no provision will be given effect which attempts to exclude, modify, disclaim or otherwise attempt to limit implied warranties of merchantability and fitness for a particular purpose.

8. **Representative's Authority To Contract:** By signing this contract, the representative of the contractor thereby represents that such person is duly authorized by the contractor to execute this contract on behalf of the contractor and that the contractor agrees to be bound by the provisions thereof.

9. **Responsibility For Taxes:** The State of Kansas shall not be responsible for, nor indemnify a contractor for, any federal, state or local taxes which may be imposed or levied upon the subject matter of this contract.

10. **Insurance:** The State of Kansas shall not be required to purchase, any insurance against loss or damage to any personal property to which this contract relates, nor shall this contract require the State to establish a "self-insurance" fund to protect against any such loss of damage. Subject to the provisions of the Kansas Tort Claims Act (K.S.A. 75-6101 et seq.), the vendor or lessor shall bear the risk of any loss or damage to any personal property in which vendor or lessor holds title.

11. **Information: No provision of this contract shall be construed as limiting the Legislative Division of Post Audit from having access to information pursuant to K.S.A. 46-1101 et seq.**

12. **The Eleventh Amendment:** "The Eleventh Amendment is an inherent and incumbent protection with the State of Kansas and need not be reserved, but prudence requires the State to reiterate that nothing related to this contract shall be deemed a waiver of the Eleventh Amendment."