TECHNICAL PROPOSAL for
ASSESSMENT OF THE DATABASE FROM THE PAVEMENT SUBGRADE PERFORMANCE STUDY

ESCINC will undertake this effort in coordination with an expert consultant, Dr Stefan Romanoschi. *Dr. Edel Cortez of Cold Region Research Laboratory (CRREL) will provide technical assistance for up to 40hrs.*

ABSTRACT

A national pooled fund study supported by 19 states, the FHWA and the U.S. Army Corps of Engineers was conducted at the Cold Region Research Laboratory (CRREL) of the U.S. Army Corps of Engineers in Hanover, New Hampshire. The study entitled the Pavement Subgrade Performance Study (PSPS) aimed to develop failure criteria and prediction models for permanent deformation in the subgrade soil that incorporate the effect of soil type and moisture content. Full-scale pavement structures were built with the same crushed stone base and asphalt concrete surface layers on top of four types of subgrade soils. Each of the four soils was placed at three in-situ moisture contents: the optimum and two other contents above the optimum. The pavements were subjected to full scale accelerated pavement testing; the MARK IV HVS machine was used as the loading device. Even though an extensive volume of response and performance data was collected in this study, limited analysis of the results has been performed.

This document presents a proposed plan for the in-depth assessment of the data obtained in the PSPS study and the drafting of a Work Plan for the development of Second Generation Design Models for subgrade materials for pavements from the data and results of the PSPS study.

1. INTRODUCTION

The project entitled "Pavement Subgrade Performance Study" (PSPS) funded through a state pool fund by FHWA was conducted at the Cold Region Research Laboratory (CRREL) of the U.S. Army Corps of Engineers in Hanover, New Hampshire, between 1999 and 2007. The project aimed to develop prediction models for permanent deformation in the subgrade soil that incorporate the effect of soil type and moisture content. In this project, flexible pavements with the same granular base layer and asphalt concrete surface layer were built inside the Frost Effects Research Facility and were subjected to accelerated pavement testing.

The pavements have been built with a combination of four soil types and three moisture levels, which resulted in a total of 12 sets of pavement sections, named cells. Each of the four soil types were placed in the pits of the facility at three moisture contents. For each cell, between four and six replicate pavement sections, named windows, were subjected to accelerated pavement testing. The MARK HVS IV was used as the loading device. Up to four wheel load magnitudes were used for the windows in the same cell.

The test sections were instrumented with stress, strain, moisture and temperature sensors. Surface rutting was monitored with a laser profilometer. Falling Weight Deflectometer (FWD) tests were performed on each pavement section before and during the application of accelerated traffic. The project was finalized and the final report was submitted in January 2007 (Cortez et al., 2007). The detailed results and data obtained in this experiment are available; a data report was submitted for each cell of pavement sections, along with a compiled database of raw data. The final report contains a description of the work conducted, as well as some limited analysis of the data.

This document presents a proposed plan for the in-depth assessment of the data obtained in the PSPS study and the drafting of a Work Plan for the development of Second Generation Design Models for subgrade materials for pavements from the data and results of the PSPS study.

The PSPS study is unique. It is the only research study that has recorded permanent deformation data in the subgrade soil under accelerated pavement testing, for such a large factorial of soil types and moisture contents. The bonanza of data this study has recorded can lead to development of advanced models for permanent deformation in subgrade soil layer, which will likely improve significantly the current design methods for asphalt pavements. Thus, it is imperative to conduct an in-depth assessment of the data obtained in the PSPS study.

2. BACKGROUND

2.1 Rutting and Permanent Deformation Models

Rutting is the formation of longitudinal depressions in the wheel paths with small amount of upheaval on the sides of the ruts due to the load induced permanent deformation in the pavement layers. This permanent deformation can occur in the subgrade, the base or subbase layers, or in the asphalt concrete layers. The magnitude of rutting and the contribution of each layer to the total permanent deformation depend on the magnitude and the lateral position of the wheel loads, the stresses in the individual pavement layers and the relative strength of the pavement layers. This later factor may change with temperature in the asphalt concrete layers and moisture regime in the unbound granular layers. Rutting develops progressively with the number of traffic load applications and is caused by the densification and shear deformation of the materials in the pavement structure.

Although rutting can occur in any layer of the pavement structure, almost all rutting prediction models assume that rutting is primarily related to the vertical compressive strain (ε_v) at the top of the subgrade soil layer. Historically, this correspondence was developed in the 1960s and the 1970s, as the result of field observations of the failure of flexible pavements with relatively thin asphalt concrete layers. However, experience has proved later that the permanent deformation may develop in the unbound base and subbase layers as well as in the asphalt concrete layers, especially for structures with thick asphalt concrete layers, where the subgrade is well protected by the pavement layers above. A method to estimate the contribution of each layer to rutting of hot mix asphalt pavements based on the shape of the transverse profile at the pavement surface was developed as part of NCHRP Project 1-34A (White et al., 2002).

Many field studies have indicated that rutting may occur in the asphalt concrete surface layer only. This indicates a mix design problem, rather than a structural design deficiency. Extensive work has been conducted on this topic as part of the SHRP's Superpave Program. The implementation of the Superpave mix design and binder characterization methods has significantly reduced the occurrence of rutting in asphalt concrete layers.

A comprehensive discussion on the development of rutting in flexible pavements is given by Ullitz (2000), Long et al. (2002) and Huang (2003). They indicated that rutting and/or permanent deformation is typically modeled by:

- estimating of permanent deformation with the layer materials modeled using visco-elastic, visco-elasto-plastic or plastic models. These models are derived based on fundamental principles of visco-elasticity and plasticity.
- computing the permanent deformation using empirical relations developed from distress data, collected on in-service pavements. These models are typically incorporated in a pavement management system environment and have a low degree of accuracy.
- estimating the number of load repetitions that will generate a certain permanent deformation or rut depth defined as failure criteria using transfer functions. These transfer functions typically relate the number of load repetitions to the magnitude of stresses or strains at critical locations in the layered system.

Table 1 lists the major transfer functions, equations that relate the vertical compressive strain (ε_v) at the top of the subgrade soil layer with the number of repetitions (N_r) of the load generating that strain, that induce a rut depth equal to a failure limit (e.g. 20 mm). The models developed above were derived based on observed deformation of in-service pavement structures. They are empirical and do not always reflect the contribution of the other pavement layers to rutting.

When incorporated in mechanistic-empirical design procedure for flexible pavements, the equations in Table 1 were used to compute the cumulative pavement damage with the aid of Miner's law. The law was developed originally to predict metal fatigue but has been applied to other materials and forms of distress. The Miner's law is expressed by the following relationship:

$$D = \sum_{i=1}^{k} n_i / N_i$$

n_i - number of applied loads in condition i

N_i - number of allowable repetitions in condition i

For each load conditions, the Miner's law calculated the corresponding damage fraction consumed. The life of the pavement is considered consumed when the total damage, D, equals or exceeds unity. Although Miner's law is incorporated in most mechanistic-empirical design methods, according to Wirshing and Yao (1976), it fails to predict accurately pavement material behavior because it does not account for the order the loads are applied and ignores the presence of an endurance limit.

TABLE 1 Transfer functions for subgrade rutting models

1. Chevron Model (20 mm rut depth)

$$N_r = 1.077 * 10^{18} * (\varepsilon_v)^{-4.4843}$$

2. Shell Model (terminal serviceability = 2.5)

$N_r = 6.15 * 10^{-7} * (\varepsilon_v)^{-4}$ at 50% reliability
$N_r = 1.945 * 10^{-7} * (\varepsilon_v)^{-4}$ at 85% reliability
$N_r = 1.05 * 10^{-7} * (\varepsilon_v)^{-4}$ at 95% reliability

3. South African Model (failure of the subgrade)

$$N_r = 1.077 * 10^{18} * (A - 10 * \log \varepsilon_v)^{-4.4843}$$
A = 33.5 for a terminal rut depth of 10mm and 36.5 for a terminal rut depth of 20 mm

3. Asphalt Institute Model

$N_r = 10^M$ where $M = 1 / [0.25*(-1.553-\log \varepsilon_v)]$

4. U.S. Army Corp of Engineers Model

$N_r = 10,000 * [(0.0002347 + 0.00245 \log E_s) / \varepsilon_v]^B$ where $B = 0.0658 * E_s^{0.559}$

N_r – number of loads until failure of the subgrade
ε_v - vertical strain at the top of the subgrade layer
E_s – subgrade resilient modulus

The major limitations of these transfer functions are:
- They are empirical in nature,
- They are valid only for the subgrade soils they were derived for,
- They are valid only for the lateral wheel wander and the tire inflation pressure they were derived for,
- They are valid only if the same definition of rut depth is used (e.g. relative to a horizontal imaginary line or a 1.2 m straight edge),
- They do not include the plastic limits or gradation of the subgrade soil
- They ignore the contribution of upper pavement layers to the permanent deformation at pavement surface.

The NCHRP 1-37A pavement design model (NCHRP, 2004) 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:

$$\delta_a (N) = \beta_1 * (\varepsilon_0 / \varepsilon_r) * \varepsilon_v * h * EXP[-(\rho/N)^{\beta}]$$

where:

δ_a – Permanent deformation for the layer/sublayer
β_1 - Calibration factor for the unbound granular and subgrade materials
ε_0, β and ρ – Material properties with $\log \beta = -0.6119 - 0.017638 * w_c$
ε_r – Resilient strain imposed in laboratory test to obtain the above listed material properties
ε_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 for β_1, were computed function 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 NCHRP 1-37A model for rutting in unbound materials was developed by modifying the models proposed by Tseng and Lytton (1989), which were developed originally based on laboratory tests and not on field measured permanent deformation data. However, the modifications have significantly altered the original models in that:

- the same shape of the model was proposed for unbound foundation materials and for subgrade soils
- the factor of bulk and deviatoric stresses were eliminated.
- The shape of the model was changed to reduce the scatter in the prediction of the permanent deformation during calibration with LTPP data, even though the LTPP database had not had data on measured permanent deformation in individual pavement layers; the permanent deformation in individual pavement layers was estimated based on an artificially selected contribution of each layer to the total permanent deformation.

The permanent deformation model for unbound materials incorporated in the NCHRP 1-37A pavement design model is empirical. However, a desirable feature is that it includes directly the effect of moisture content in the computation of permanent deformation, and not indirectly, through its effect on the resilient modulus of the foundation layers.

2.2. Summary of the results from the Pavement Subgrade Performance Study

A national pooled fund study [SPR2(208)] supported by 19 states, the FHWA and the U.S. Army Corps of Engineers was conducted at the Cold Region Research Laboratory (CRREL) of the U.S. Army Corps of Engineers in Hanover, New Hampshire (Cortez, 2007). The study aimed to develop failure criteria and prediction models for permanent deformation in the subgrade soil that incorporate the effect of soil type and moisture content. In this project, flexible pavements with the same 229 mm (9 in.) granular base layer and a 76 mm (3 in.) asphalt concrete surface layer were built inside the Frost Effects Research Facility of CRREL and were subjected to accelerated pavement testing. All pavement sections were 23 meters (75 ft) long and 6.4 m (21 ft.) wide and 3.3m (11 ft.) deep. Thus, the subgrade soil layer placed on top of a concrete floor was 3.05 m (10 ft.) thick.

The pavements have been built with a combination of four subgrade soil types and three moisture levels, which resulted in a total of 12 sets of pavement sections, named cells. Each of the four subgrade soils was placed in the pits of the facility at three moisture contents (Table 2), one of the three being the optimum moisture content. The moisture content was controlled during construction and it was assumed to remain constant throughout the accelerated pavement testing. The top 1.5 m (5 ft.) of the soil was placed in 150 mm (6 in.) lifts. The density and uniformity of the compacted soil was determined with nuclear density gages, the Clegg hammer and the Falling Weight Deflectometer.

The properties and the classifications of the four soils are given in Table 3. For each cell, between four and six replicate pavement sections, named windows, were subjected to accelerated pavement testing. Up to four wheel load magnitudes were used for the windows in the same cell. The windows were approximately 1.3 m (4.3 ft.) apart. As a result of a finite element analysis, it was assumed that loading of one window did not affect the performance of the adjacent windows.

TABLE 2 Experimental test matrix and soil parameters

Subgrade Moisture Content	AASHTO Soil Type			
	A-2-4	A-4	A-6	A-7-5
M1	Optimum 10 % TS 701	Optimum 17 % TS 702	Optimum 16 % TS 709	Optimum 20.4 % TS 712
M2	12 % TS 707	19 % TS 704	19 % TS 708	21 % (soil borderline to A-6) TS 710
M3	15 % TS 703	23 % TS 705	22% TS 706	25 % TS 711

TABLE 3 Experimental test matrix and soil parameters

AASHTO Soil Classification	Maximum Dry Density (kg/m3)	Liquid Limit	Plasticity Index	Percent Passing #10 sieve	Percent Passing #200 sieve	Percent < 0.002 mm	Specific Gravity
A-2-4	1934	30	2.1	71.8	31.2	3	2.72
A-4	1780	28	18	97.8	84.7	20	2.72
A-6	1800	29	13	99.9	98.9	52.2	2.70
A-7-5	1700	55	21	100	88	75.2	2.71

The MARK HVS IV was used as the loading device; the HVS wheel traveled at a constant speed of 12 km/h (7.5 mph) over a length of 6 meters (20ft.) Traffic was uni-directional with uniform lateral wander. A dual truck tire assembly, with a tire inflation pressure of 689 kPa (100 psi) was used to apply the accelerated traffic. The test sections were instrumented with stress, strain, moisture and temperature sensors. Surface rutting was monitored with a laser profilometer. Falling Weight Deflectometer (FWD) tests were performed on each pavement section before and during the application of accelerated traffic.

Permanent and resilient deformations at various locations in the pavement structures were measured by stacks of εmu coils. Stresses in the subgrade and base courses were measured using stress cells. Stress and strain measurements were performed for vertical, transverse and longitudinal directions. However, the stresses and strains measured in the transverse and longitudinal directions were found to be much smaller than those recorded in the vertical direction. Figure 1 is a schematic diagram showing the location of the εmu coils (Cortez, 2007).

The project was finalized and the final report was submitted in January 2007 (Cortez, 2007). The detailed results and data obtained in this experiment are available; a data report was submitted for each cell of pavement sections, along with a compiled database of raw data. The final report contains a description of the work conducted, as well as some limited analysis of the data.

The major conclusions obtained so far in the study are:

1. The contribution of the subgrade soil to the permanent deformation at the pavement surface varied greatly from one soil to another and was dependent on moisture content (Table 4). This clearly reveals that there is no unique contribution of the pavement layers to the permanent deformation at the pavement surface, as it was assumed in the national calibration of the NCHRP Pavement Design Guide. The second major consequence of this finding is that it is not useful to develop a failure criteria for permanent deformation in the subgrade layer; other layer contribute as well to the permanent deformation or rutting at the pavement surface. Surprisingly, the clayey subgrade (AASHTO soil 7-5) had the lowest contribution to the permanent deformation at the pavement surface. This suggests that the asphalt concrete and the crushed stone layers might not have been the same on all cells.

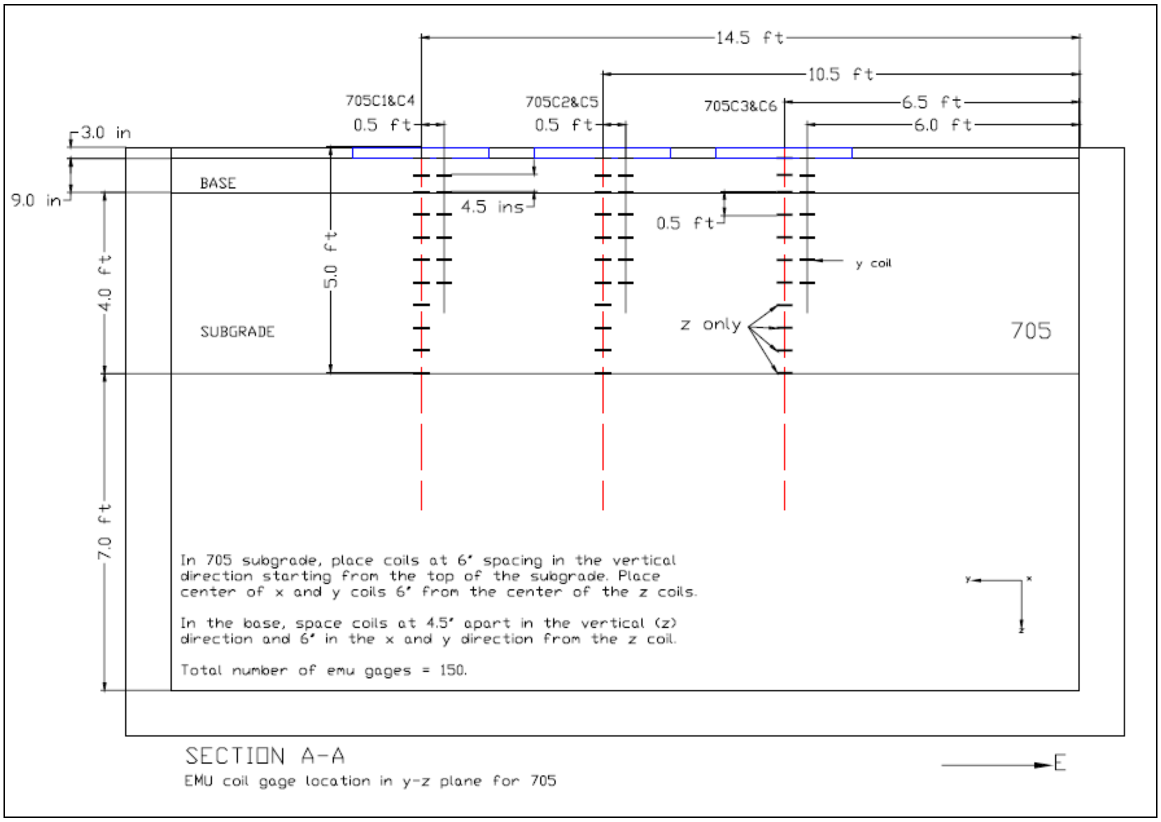

Figure 1. Cross section of test section showing the location of εmu sensors (Cortez, 2007)

2. For some soils, the lowest permanent deformation in the subgrade soil was not always recorded for the optimum moisture content. It was concluded that the optimum moisture content makes the soil achieve the maximum dry density for a given compaction effort, but it does not leads always to the highest shear strength.
3. The effect of wheel load magnitude on the development of permanent deformation in the subgrade was in most cases as expected: higher wheel loads led to higher permanent deformations. An analysis of the data led to the estimation of the damage induced to the subgrade by overloaded truck axles. However, in some instances, for the same soil type and moisture content, the highest permanent deformation was not recorded for the highest wheel load. This suggests that a more thorough look must be taken at the variability in the properties of pavements constructed in the same cell and at how this may have influenced the performance of each window.
4. Permanent deformation prediction models were developed for each of the four soil types included in the study. The models related the plastic strain to the load intensity, moisture condition and the number of load cycles. However, the models are applicable only to the geometry of the pavement structures tested in this study. As stated by Cortez (2007), “some adaptation is needed to consider the effect of asphalt and base thickness values that differ from those used in the test sections”. Moreover, no assessment of the reliability of the proposed models was provided.

TABLE 4 Percent permanent deformations in the asphalt, base and subgrade at failure

Soil Type	Cell	Moisture Content	Asphalt	Base	Subgrade
A-2-4	701	Optimum	20.0	43.0	37.0
	707	Optimum+2%	26.0	34.7	39.3
	703	Optimum+5%	15.8	37.1	47.1
A-4	702	Optimum	21.0	53.0	26.0
	704	Optimum+2%	17.0	49.4	33.6
	705	Optimum+6%	13.2	24.2	62.6
A-6	709	Optimum	12.9	56.7	30.4
	708	Optimum+2%	25.6	49.8	24.6
	706	Optimum+6%	13.3	37.5	49.2
A-7-5	712	Optimum	51.6	31.2	17.2
	710	Optimum +0.5%	50	30	20
	711	Optimum+5%	53.0	25.0	22.0

Despite of these findings, the analysis of the data conducted so far has not answered many important questions:

- What is the reliability of the data collected in the Pavement Subgrade Performance Study? Is the collected data consistent with the current concepts related to development of stresses and strains in a flexible pavement structure under a passing wheel? What data should be retained for the development of sound permanent deformation models? What additional data is needed?
- How the results of this study relate to similar field and laboratory studies conducted in the United States and overseas to study permanent deformation in subgrade layers?
- Using data from this study alone, what is the most reliable model for predicting permanent strain in the subgrade soil? Is it better to employ the same permanent strain model for all soils, or each soil would require a different model?
- Can sound models for predicting permanent strains in the subgrade soil from resilient strain and vertical stresses be developed from the data collected in the project? Is it better to include statistical reliability concepts in the development of such models, to enhance their effectiveness?
- Is the model employed in the NCHRP M-E Design Guide an effective and reliable model for all soils? If yes, what are the model's parameters for the four soil tested in the study?

It is thus clear that only limited analysis and quality checks have been conducted on the data collected in the *Pavement Subgrade Performance Study*.

This study is unique in that it is the only research study that has provided permanent deformation data in the subgrade soil recorded under accelerated pavement testing, for such a large factorial of soil type and moisture contents. The bonanza of data this study has collected can lead to development of advanced and new models for the accumulation of permanent deformation in subgrade soil layer, which may improve significantly the design methods for asphalt pavement structures. However, because of the complexity of data collected, in terms of the number of variables involved and the sheer volume of the data and some incomplete/missing data, an in-depth detailed assessment of the data obtained in the PSPS study is needed to facilitate further analysis and model development. Since the interagency agreement between

FHWA and CRREL has expired and the funds have exhausted, it is imperative to conduct the in-depth data assessment in a new research project.

The in-depth analysis of the data and the development of sound permanent deformation models require:

- The evaluation and validation of the data collected in the Pavement Subgrade Performance Study. The assessment and validation of the data has not been done due to the very large volume and the complexity of the data collected (e.g. interaction between variables). Incomplete, missing and erroneous data also needs to be identified.
- Conversion of current database in a new format facilitating the use of the data (e.g. Microsoft Access database). In the current form, the data is reported in tabular form in Microsoft Excel spreadsheet format. In this format the data can be easily visualized but it cannot be imported in statistical software packages (e.g. SAS, SPSS, Statistica) for model development. A catalog and a dictionary of the data currently available are also needed.
- A work plan for the data analysis and the development of advanced permanent deformation models. Such a work plan can be prepared only after an in-depth knowledge of the collected data and the comprehensive review of the current models and concepts related to permanent deformation of subgrade soils.

3. OBJECTIVES

The objectives of the proposed research project are:

- To review in detail the data collected in the Pavement Subgrade Performance Study and to check for completeness and for quality and consistency with the pavement engineering principles and with other similar field and laboratory studies conducted in the United States and overseas;
- To assemble additional available data, including laboratory test results, to enhance the current database;
- To convert the enhanced database in a new format which will allow easy import in statistical or other analytical software packages;
- To develop the catalog and dictionary for the data assembled in the enhanced database;
- To prepare a detailed work plan for future data analysis and modeling, to facilitate the development of Second Generation Design Models for subgrade materials for pavements from the data and results of the Pavement Subgrade Performance Study.
- *Obtain construction quality assurance testing and forensic testing from all cells.*

4. STATEMENT OF WORK

The objectives will be achieved by performing the following tasks:

TASK 1. Literature Search - A literature search will be conducted to gather information on previous studies on permanent deformation of subgrade soils, and other field or laboratory full-scale accelerated pavement tests conducted in the United States and overseas that investigated the performance and permanent deformation of subgrade soils.

TASK 2. Review of Data and Results from the Pavement Subgrade Performance Data – The entire literature related to the Pavement Subgrade Performance Study, including the data, research reports and journal articles will be reviewed in detail in this task. The database will be reviewed for its reasonableness, consistency and completeness. A report documenting the inconsistent, missing or erroneous data will be prepared in this task.

TASK 3. Assembling of Additional Data –Additional available laboratory test results and missing data will be assembled. At this stage, it is envisioned that the following may be done in this task:

- backcalculation of the layer moduli from the collected FWD deflections
- comparison of collected response data with theoretical values estimated by linear elastic pavement response models
- visits to CREEL and material suppliers (e.g. asphalt contractor) to collected missing data related to material properties and construction process.

TASK 4. Development of a New and Enhanced Database - In this task, a new database containing comprehensive and validated data set suitable for complete use of the field and laboratory experiments conducted for the National Pooled-Fund Study SPR-2(208) will be developed. The current database and the additional data collected in Task 3 will be converted in a new database, in a new format facilitating the use of the data; Microsoft Access database is the format proposed at this stage. The current database was delivered in tabular form in Microsoft Excel spreadsheet. In this format the data can be easily visualized but it cannot be imported in statistical software packages (e.g. SAS, SPSS, Statistica) for model development. A documentation cataloging the data set, format, and data dictionary to accompany the database will also be prepared in this task.

TASK 5. Preparation of the Work Plan - A Work Plan for further analysis of the data will be prepared in this task. The Work Plan will give detailed information on the recommended laboratory test program, if needed, statistical or other numerical analysis methods to be used in the development of permanent deformation models for subgrade soils. For example, at this stage it is envisioned that statistical reliability could be used effectively to develop permanent deformation models. This is because in the Pavement Subgrade Performance Study, replicate sensors embedded in the pavement structures provided multiple response and performance measurements for the same location and experimental conditions (soil type, moisture content, wheel load, number of passes).

Task 6. CRREL Technical Assistance– *The proposed task consists of technical assistance to the designated data analysis and modeling team to navigate the existing database of stress, deformation, rutting and strains produced based on accelerated pavement testing within the Pavement Subgrade Performance Study, and to provide direction to the information on the available construction quality control and forensic test data. The technical assistance will be provided by Dr. Edel Cortez and limited to a total of 40 hours of labor, including planning and coordination for the meeting. Except for a planning phone call, the work will be performed at a date to be coordinated, not earlier than January 2009. No travel under this task is included in the cost estimate and the work will be performed from Hanover, NH.*

5. DELIVERABLES AND DUE DATES

- Report of the data assessment with recommendation for data addition and removal. *March 31, 2009 (after completion of Tasks 1, 2 and 3).*
- A database containing comprehensive and validated data set suitable for complete use of the field and laboratory experiments conducted for the National Pooled-Fund Study SPR-2(208). A documentation cataloging the data set, format, and data dictionary will accompany the database. *June 30, 2009 (after completion of Task 4)*.
- Work Plan for the development of Second Generation Design Models for subgrade materials for pavements. *August 31, 2009 (after completion of Task 5)*.

Additional deliverables will be determined as work progresses and as directed by FHWA COTR and the Steering Committee.

6. PERIOD OF PERFORMANCE

The work described in this scope of work will be completed by September 30, 2009.

7. TIMELINE

The timeline for this project is given below:

	TIMELINE												Total Hours
	Oct 2008	Nov 2008	Dec 2008	Jan 2009	Feb 2009	Mar 2009	Apr 2009	May 2009	Jun 2009	Jul 2009	Aug 2009	Sep 2009	
Task1	20	15	10	5									50
Task2	20	30	35	35	30	25							175
Task3		5	20	25	10	15							75
Task4							40	40	20				100
Task5								10	***10***	***10***	***15***	15	***60***
TOTAL Hours	40	50	65	65	40	40	40	50	30	10	15	15	***460***