Strain in the asphalt concrete is calculated using analytical procedures for structural analysis of the pavements. The repetitions to failure is based on the cumulative damage hypothesis which is the mechanism which results in fatigue cracking.

Both strain and modulus are a function of asphalt and asphalt-aggregate properties in the above illustration; hence, the model would be a candidate for predicting fatigue cracking.

A limited number of models have been developed to predict deformation. The permanent deformation model selected will include provision for asphalt properties and mixture properties for both short (0.01 seconds) and long periods of loading (1 hour) as required to simulate field loading conditions under moving loads and standing loads.

The permanent deformation model will also include provisions for evaluating effects of various wheel loads, configurations, tire pressures and mixture temperatures.

Several models exist which relate laboratory fatigue characteristics of asphalt bound materials to mixture properties such as stiffness (dynamic modulus, complex modulus, etc.) and air voids. These models will be evaluated and modified as necessary to improve their reliability. If currently available models are considered unsatisfactory, new models will be developed.

In addition to material properties, including those of asphalt and asphaltic concrete, the model shall consider: wheel loads and configurations, time of loading, effect of mixed traffic, tire pressure and temperature cycles.

Models have been developed for the prediction of low temperature cracking. These models relate the occurrence of transverse cracking to asphalt properties and asphalt mixture properties. In selecting the low temperature transverse cracking model(s), consideration will be given to rate of change in temperature (i.e., temperature drop), the influence of friction between the supporting layer, and age hardening of asphalt and asphalt-aggregate combinations.

The low temperature model will be capable of predicting cracks resulting from a single thermal cycle as well as repeated cycles over long periods of time, i.e., 15 to 20 years. The model will provide some means for predicting the cracking index or average expected frequency (spacing) of cracks.

This project does not involve any testing; it is primarily an investigation of models; mechanistic, mechanistic-empirical or empirical which can be used to predict specific types of performance based on asphalt properties or asphalt-aggregate properties.

Specific requirements for this task include:

1) Develop performance prediction models for each of the three types of distress identified.

2) Describe methods for validation of models including the need for and type of field data required.
A total of 0.5 million dollars has been allocated to this task.

**Task 3.2  Asphalt Performance Studies**

**Objective:** The objective of this task will be to obtain as much documented performance information as possible from as many sources as possible in an effort to establish criteria which will be used for asphalt specifications and for the design of asphalt-aggregate mixtures.

**Scope:** The scope of this task includes: 1) observations of field performance, 2) collection of samples and performances of tests necessary to evaluate prediction models and 3) development of empirically based fitting coefficients to calibrate models to observed performance. Emphasis in data collecting, sampling and testing will be given to projects with long term performance records and for which samples of the original asphalt and aggregate are available for testing.

The task will include the following activities:

1) Develop a sampling and testing program for in-service pavements.
2) Summarize and analyze field and laboratory data.
3) Develop empirical coefficients to adjust theoretical models from 3.1 to applied prediction models.
4) Develop procedures for updating empirical coefficients.

Planning for this task will require a well-planned experiment which will provide information indicative of differences due to materials and environments.

This task will involve collection of performance data from any source considered useful for evaluation of prediction models and for establishing specification or mixture design requirements. A laboratory testing program necessary to support prediction models will be required.

**Specific requirements for this task include:**

1) Obtain samples of asphalt-aggregate materials from designated in-service pavements.
2) Conduct necessary testing program to develop information required to evaluate prediction models for a) fatigue cracking, b) permanent deformation, c) low temperature cracking and d) reflection cracking.
3) Analyze performance information and test data to establish specification requirements and criteria to be used with asphalt-aggregate analysis system.

A total of 3.0 million dollars has been allocated to this task.

**Task 3.3(3)  Evaluation Procedures for Prediction Models**

**Objective:** This task will provide guidelines for state highway agencies to maintain and update performance prediction models and to modify specification requirements recommended in task 4.2.
**Scope:** The scope of this task will include the development of methods for interpreting information from the Long Term Pavement Performance research area (TRA 2) as it applies to TRA 1 objectives, and to develop a comprehensive satellite SHRP program for future enhancement of specifications based on a well-planned experiment design and data acquisition requirements.

This task will involve methods to be used for obtaining and analyzing research information useful for updating (improving) prediction models and for revising specification requirements for binders of all types, i.e., asphalt, recycled asphalt or modified asphalt. Criteria and recommended procedures to be used in establishing local or national satellite SHRP research will be developed. Mathematical examples with hypothetical or real data will be analyzed to illustrate the recommended procedures. No testing, laboratory or field, will be required for this task although data useful in illustrating procedures may be acquired from other tasks within TRA 1.

**Specific requirements for this task include:**

1) Develop mathematical guidelines to be used for evaluation of prediction models from performance data. Relate such procedures to future interpretation of LTPP data.

2) Prepare a step by step procedure for establishing data requirements and analysis procedures to be used in updating specification requirements and design criteria for incorporation in the asphalt-aggregate mixture analysis system.

3) Prepare experiment design recommendations for use at the local or national level for obtaining information required to increase the data base of information useful for future updating of goals established for TRA 1; in effect, a planned SHRP satellite program.

4) Illustrate the step by step procedures for interpreting information from experiment design in items 3 above; use hypothetical or real data as is available and is appropriate.

A total of 1.0 million dollars has been allocated to this task.

**Project 1-4 Preparation of Performance-Based Specifications and an Asphalt-Aggregate Mixture Analysis System**

This project will prepare performance-based specifications for asphalt and recommendations for a comprehensive mixture design method to be referred to as an asphalt-aggregate mixture analysis system (AAMAS).

For purposes of this project, a performance-based specification for asphalt must satisfy the following requirements:

1) It must be based on standardized tests which have been shown to satisfy requirements of ASTM and AASHTO.

2) It should include measurements (test data) which have been related to performance.

3) It should be based on types of performance which can be defined quantitatively.

The asphalt-aggregate mixture analysis system will describe laboratory procedures and requirements for the laboratory evaluation of...
asphalt binders, virgin, recycled or modified, and aggregate to minimize the occurrence of fatigue cracking, low temperature cracking and permanent deformation. The system will be sensitive to asphalt binder properties, aggregate properties and regional factors which could influence mixture performance.

The project will be divided into two tasks: 1) performance-based specifications for asphalt and 2) development of an asphalt-aggregate mixture analysis system.

The performance-based specifications for asphalt and asphalt-aggregate systems will incorporate the findings of each of the projects included in this research area. It is acknowledged that a limited amount of field performance information will be available during the term of the project, i.e., five years. It will, therefore, be necessary to develop an interim or model specification for recommendation at the completion of the project but which can be modified (improved) as additional information becomes available.

**Task 4.1(3) Performance-Based Specifications for Asphalt**

**Objective:** The objective of this task will be to develop performance-based specifications for asphalts, with and without modification. A sufficient number of specifications will be formulated to accommodate a wide variety of conditions which can be encountered in the United States.

**Scope:** The development of the asphalt specifications will fully consider the following requirements.

1) Will be tolerant to a wide range of mixing temperatures without damaging the asphalt and adversely affecting its desirable mixing and placing characteristics or its long-term performance in-service.
2) Will not be adversely affected by the chemical and physical properties of the aggregate used in the mix.
3) Will develop the needed adhesion (i.e., bond) to aggregates of different composition at different temperatures and degrees of wetness.
4) Will be resistant to migration (i.e., bleeding) at high temperatures.
5) Will be resistant to the adverse effects of aging (i.e., long-term durability).
6) Will remain flexible at in-service temperatures and resistant to cracking at low temperatures.

**Specific requirements for this task include:**

1) Select significant properties and their related test methods for use in the specifications.
2) Specify limits for the properties measured by the applicable test methods for each type and grade of asphalt included.
3) Provide guidelines for selecting asphalt grades for use in different environments, types of construction and characteristics of traffic.
Each specification will be the result of that combination of the above requirements considered to be "optimal," all factors considered.

A total of 3.0 million dollars has been allocated for this task.

**Task 4.2(3) Performance-Based Specification for an Asphalt-Aggregate Mixture Analysis System (AAMAS)**

**Objective:** The objective of this task will be to develop a performance-based specification for an asphalt-aggregate mixture analysis system (AAMAS), utilizing asphalts with and without modification.

**Scope:** The asphalt-aggregate mixture analysis system will include guidelines for specifying the properties of the asphalt-aggregate mixture which will produce a mix with the following characteristics:

1. Resistant to creep and permanent deformation (i.e., rutting).
2. Resistant to repeated bending stresses and strains (i.e., fatigue).
3. Resistant to low temperature cracking (i.e., thermal cracking).
4. Resistant to aging in-service at relatively high air voids (i.e., long-term durability).
5. Resistant to the effects of moisture and water (i.e., water sensitivity).
6. Compactible over a wide temperature range.

**Specific requirements for this task include:**

1) Select test methods considered necessary and sufficient for use with AAMAS.
2) Designate required specification limits for properties measured by the applicable test method for the full range of design considerations.
3) Provide guidelines for implementing AAMAS.

Typical examples of the application of AAMAS to situations representative of the variety of environments, types of construction and traffic loading characteristics encountered throughout the United States will be presented.

A total of 2.0 million dollars has been allocated for this task.

**Project 1-5 Coordination**

The objective of the coordination project is to assure that the combined effort from each task will adequately focus on the requirements for TRA 1. In order to achieve this objective, coordination has been divided into five tasks as described herein.

**Task 5.1 TRA 1 Research Project Coordination**

The objective of this task will be to monitor the activities of each project and task and to establish a mechanism for interaction between each ongoing research activity.
An important responsibility for the TRA 1 project coordination will be to interface the work under NCHRP 10-26(A) and 9-6(1) with activities in TRA 1. These two projects could contribute to the work under the following tasks:

2.2 - Testing and measuring methods for asphalt-aggregate systems
2.3(2) - Relationships between asphalt properties and asphalt-aggregate mixture properties
3.2 - Asphalt pavement performance studies
4.2 - Performance-based specifications for asphalt-aggregate mixture analysis system

Depending on the results from these two NCHRP projects, it may be desirable to modify the scope of work under any of the above tasks or, in the case of task 4.2, to accelerate activities by at least one year.

Specific requirements for this task include:

1) Schedule monthly meetings for representatives from each active research task or subtask in order to exchange and discuss specific accomplishments and problems.
2) Assist in resolving problems in order to achieve on time results.
3) Organize quarterly meetings of user-producer advisory committee to summarize results of research activities. (Note: If this committee is organized, it would be appointed by SHRP office with approval by the Task Force).
4) Provide quarterly executive summaries of progress on each research activity in progress indicating achievements, problems and overall evaluation.

A total of 1 million dollars has been allocated to this task.

Task 5.2 Operate Materials Reference Library

The objective of this task will be to develop and maintain a "library" of asphalts, aggregates and modifiers for use by contract agencies and other interested and authorized organizations.

The contractor will be required to procure asphalts and aggregates in suitable quantities to support the TRA 1 research activities. The cost of procurement, transport, storage, cataloging, packaging and shipping will be included in this project.

The specific requirements for this task include:

1) Procure samples of asphalts, aggregates and modifiers necessary to support research and long term requirements for TRA 1.
2) Store materials in proper containers or areas to minimize any changes in properties with time.
3) Package and ship materials to authorized users and in sufficient quantity to support specified research activities.
4) Monitor properties of materials in order to determine if specific properties are changing and by how much and if additional precautions are necessary to assure stable properties.

TRA 1-51
A total of 1.5 million dollars has been allocated to this task.

**Task 5.3 Experiment Design**

The objective of this task will be to develop a statistically sound experimental design for each research activity and to prepare a coordinated plan for selecting and testing materials. As a minimum the following items will be considered:

1. data requirements,
2. data storage and transmittal to the central data bank,
3. type and number of materials required to satisfy objectives of TRA 1 and
4. data analysis methodology.

**Specific requirements for this task include:**

1) Provide input and coordinate experiment design requirements for each task and subtask.
2) Provide assistance in planning for data acquisition and data analysis for each task and subtask.
3) Provide assistance in furnishing data to the central data bank to be established for SHRP projects.
4) Coordinate plans for the asphalt study area with requirements for the Long Term Pavement Performance Study Area.

A total of 0.5 million dollars has been allocated for this task.

**Task 5.4 Economic Considerations**

The objective of this task will be to provide expertise in evaluating the economic consequences of implementing specific findings from TRA 1 research activities. Preliminary indications from knowledgeable persons from both user and producer groups suggest that efforts to improve the properties of binders by introducing new asphalt specifications, or by the use of modifiers may increase the unit cost of binder systems. If this increased cost can be offset by either more reliable performance or an extended life cycle the overall benefits of increased initial cost would be justified.

A defensible method for making life cycle cost or benefit-cost comparisons will need to be established.

**Specific requirements of this task include:**

1) Provide a centralized group to study and evaluate the effectiveness of introducing new asphalt specifications and asphalt-aggregate requirements.
2) Prepare reports summarizing economic analysis procedures including assumptions required to estimate life cycle cost analysis and benefit-cost ratios.
3) Prepare estimates of the possible national benefits of introducing specific changes in asphalt-aggregate mixture requirements.
In order to encourage and facilitate implementation of the research findings, it will be necessary to assemble information appropriate for use by user agencies into a series of implementation packages. Such information will include as a minimum:

1. preparation of material for SHRP to use in newsletters,
2. preparation of reports detailing the benefits of research findings and
3. conduct of regional workshops to explain research findings and to recommend procedures for implementation.

Specific requirements of this task include:

1) Prepare information regarding how to obtain materials and prepare construction specifications for incorporation of research findings.
2) To provide a step by step procedure for implementing research findings to be applied to site specific conditions.
3) Prepare specific information for use by SHRP officials in making presentations to Congress, AASHTO or other selected groups.
4) Prepare information for use by SHRP in preparing news releases.
5) Plan and conduct workshops in the fifth year of SHRP to explain findings and benefits available by implementing research results.

A total of 0.4 million dollars has been allocated to this task.