Asphalt-Rubber Research and Development

An Industry Commitment to Excellence

Dedicated to promoting great usage of high quality, cost effective asphalt pavements containing recycled tire rubber.

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TAB Mission Statement

Advance engineering technology and implementation of Asphalt-Rubber.

Goals:

- **Provide policy and technical counsel to the RPA Board of Directors.**
- **Provide technical insight and direction.**
- **Assist in establishing technical merits and values of Asphalt-Rubber.**
- **Identify, formulate and monitor research.**
- **Lead development and delivery of training education.**

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Asphalt-Rubber Research and Development
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Introduction

Of the 2.3 million miles of paved highways in the United States, nearly 95 percent are paved with asphalt. Many of these highways have exceeded their design life and will require reconstruction, rehabilitation, and maintenance if they are to continue to adequately serve the public. Hot mix asphalt (HMA) and asphalt surface treatment are used as the predominate material in pavement construction, reconstruction, rehabilitation, and maintenance projects. Rehabilitation of existing pavements is a high priority among local, state and federal transportation agencies. This will continue to be of vital importance for many years. A few states and local agencies recognize that a cost-effective method for rehabilitation involves an appropriate use of Asphalt-Rubber in pavements.

Each year approximately 250 million tires are discarded in the United States, or about one tire per person per year. Of that figure nearly 200 million tires are added to stockpiles, landfills, and illegal dumps across the country. The Environmental Protection Agency (EPA) estimates that more 2 billion tires are stockpiled in the United States. A potential use for a significant number of tires is to expand the use of Asphalt-Rubber in HMA construction and highway maintenance activities.

Ground Tire Rubber (GTR) has been used in asphalt for highway pavement construction since the mid-1960's. Although the technology for rubber-modified asphalt has been used for nearly four decades, engineers have not universally accepted systematic design and testing procedures. Ground tire rubber can be blended with hot liquid asphalt, resulting in a product known as Asphalt-Rubber. This modified asphalt can be used to make any of the various types of asphalt pavements produced using conventional asphalt.

Utilization of Asphalt-Rubber in pavement construction has been fragmented, and the technical merits for using Asphalt-Rubber products are not well understood. The continued emphasis on recycling and reported good performance by some states warrants a better understanding of the merits of Asphalt-Rubber products used for construction activities. This report outlines research and development activity needed to ascertain the quality and performance of Asphalt-Rubber pavement construction.

The Rubber Pavements Association (RPA) is a nonprofit organization committed to increased awareness and advancement of Asphalt-Rubber technology. RPA only supports those paving processes that combine a long history of laboratory research and proven field performance. RPA is dedicated to encouraging greater usage of high quality, cost effective asphalt pavements containing recycled tire rubber.

This strategic research plan by RPA to define Research & Development (R&D) needs for asphalt rubber HMA was developed by the Technical Advisory Board (TAB) of RPA and summarizes the meeting in Reno, NV of the TAB on July 11 and 12, 2000. The programs and projects outlined here will be continually changing, as public transportation needs change. This document sets forth a five year strategic plan for R&D for Asphalt-Rubber technology.

Joint discussion and funding of research will improve the performance of an already exceptional product. The RPA is committed to working with State agencies and the FHWA to advance the state-of-the-art by undertaking research projects outlined in this document.

Background

Dating back to the 1920's, engineers and chemists tried, with limited success, to incorporate rubber into asphalt. In the 1960's, Charles McDonald, who was City of Phoenix engineer, developed the first successful time/temperature formula for incorporating scrap tire rubber into an asphalt paving material. This technique is widely known as the "wet process". During the nearly four decades since the development of Asphalt-Rubber, use has evolved from spray-applied asphalt rubber chip seals, to using reacted rubber asphalt as a binder in HMA.

The use of reclaimed GTR as an additive in bituminous products would help to solve a waste disposal problem, and when properly designed and constructed, improve pavement properties. Acceptance of HMA containing GTR has been generally regional, depending primarily on the favorable experience of experimental construction. The performance of HMA systems containing GTR has been fragmented and difficult to assess. Both field and laboratory data on Asphalt-Rubber materials has been limited and without continuity.

Successful utilization of Asphalt-Rubber in HMA requires critical engineering evaluation. A mix design must be developed which incorporates GTR, aggregates and asphalt to meet expected design requirements. Layer thickness must be considered to ensure performance life of the pavement. Lastly, construction procedures must be developed and followed to ensure that the mix and structural requirement are met in the field.

Pavement rehabilitation remains a high priority among State Highway Agencies (SHA's). Strategic Highway Research Program (SHRP) research for improving asphalt technology yielded significant improvement for HMA design and construction, by emphasizing Performance Grade (PG) binders, volumetric mixture design criteria, and the Superpave Gyratory Compactor (SGC) for laboratory compaction of asphalt specimens. Despite the significant effort by SHRP to improve HMA, there remains a critical need to improve pavement rehabilitation procedures. While Asphalt-Rubber products can be used for highway pavement rehabilitation programs, significant research remains to be done to optimize Asphalt-Rubber activities. Specifically, research is needed to link Asphalt-Rubber technology to SHRP's research.

The RPA is committed to be involved in R&D activities related to Asphalt-Rubber, to stay abreast of developments, to have input into the research project development system, and to jointly fund R&D activities to ensure engineering requirements are considered in the process. The overall goal is to focus research, development, and implementation activities on improving the quality of Asphalt-Rubber HMA. RPA believes that research accomplished in a collaborative mode is more easily implemented and reaps far greater gains than research accomplished without the industry input and involvement.

The stage of implementation for research and development is often missing in past research. RPA believes that research and development must be properly implemented if the results of the research are to be realized. They further believe that research accomplished jointly with others is more easily implemented.

An Industry Commitment to Excellence

The Rubber Pavements Association (RPA) is committed to continuously improve the performance of Asphalt-Rubber products. An on going R&D program is vital to address unresolved technical issues related to asphalt rubber. This report represents an effort on the part of private industry to identify technical needs for Asphalt-Rubber products.

This report demonstrates the need for strong partnerships between agencies and private industry. Each project described shows a potential partnership, which includes either the AASHTO member departments or the Federal Highway Administration. Such partnerships are critical for project definition, funding and implementation of the findings. Clearly, the result of team effort is much better than any product produced independently.

The Technical Advisory Board (TAB) is pleased to present this report as a cornerstone in RPA's commitment to the further development of asphalt rubber products.

PROJECT 1

VOLUMETRIC MIXTURE DESIGN PROCEDURES FOR ASPHALT-RUBBER MIXTURES

Introduction

The first step in construction of any hot mix project is a mixture design based on the project aggregates and binder. The mixture design involves selecting the best combination of aggregates proposed for use in the project to meet the aggregate gradation specification and the desired asphalt-aggregate mixture properties. In addition the optimum asphalt binder content must be determined.

In the course of a typical mixture design, aggregate gradation is selected based on available stockpiles and the master gradation requirements of the specification. The optimum asphalt binder content is determined in the laboratory such that volumetric property (such as air voids content, Voids in Mineral Aggregate and Voids Filled with Asphalt) requirements are satisfied.

Background

Marshall and Hveem methods of mixture design have been extensively used in design of Asphalt-Rubber mixtures. The Marshall design method is based on the Marshall compaction hammer and the Marshall stability and flow parameters. California kneading compactor or Texas Gyratory press along with Hveem stabilometer are used in the Hveem mixture design procedure.

Asphalt-Rubber binder, due to the high percentage of crumb rubber in the binder has unique elastic properties, which must be considered in the mixture design process. Laboratory testing protocols and test procedures used in the mixture design process are modified in response to elastic properties of the binder. Modifications to Marshall and Hveem design procedures have been developed to account for unique characteristics of Asphalt-Rubber binders.

Superpave Gyratory Compactor (SGC) represents the latest technological advance in laboratory compaction of asphalt mixture specimens. Many state Departments of Transportation as well as local municipalities have adopted Superpave Volumetric design procedures and the number of agencies converting their design and quality control procedures to utilize SGC is growing. There is a need to evaluate Asphalt-Rubber mixtures in SGC and develop proper test protocols for designing Asphalt-Rubber mixtures with Superpave Gyratory Compactor.

Objectives and Scope

The objective of this project is to document the existing Marshall and Hveem design procedures and to develop a mixture design procedure utilizing Superpave Gyratory compactor.

Work Plan

Task 1. Existing Procedures

Collect information from states such as California, Arizona and Texas and document the existing mixture design procedures for use with California Kneading compactor, Texas Gyratory press and Marshall hammer. The documentation must be in AASHTO format for test methods and specifications.

Task 2. Conduct Laboratory Tests Using SGC

Conduct laboratory tests on selected Asphalt-Rubber and several aggregates to establish the following parameters:

- ?? **Mixing, curing and compaction temperature for use with SGC**
- ?? **Compaction and sample handling procedures for use with SGC. It is anticipated that only one N-design level will be utilized in this study.**
- ?? **Document the mixture design procedure for design of Asphalt Rubber mixtures in AASHTO format.**

Duration

12- 18 months.

Estimated Costs

$125,000-$150,000

Products

Guide document for design of Asphalt-Rubber mixtures utilizing Superpave Gyratory Compactor, Marshall Hammer, California Kneading Compactor and Texas Gyratory Press will be prepared.

Potential Partners

Selected state highway agencies, FHWA, NCAT, University of Nevada-Reno, and Clemson University.

PROJECT 2

PG BINDER SPECIFICATIONS FOR ASPHALT RUBBER BINDERS

Introduction

One of the products of asphalt research program of the Strategic Highway Research Program (SHRP) is the Performance Grade (PG) specification for asphalt binders. This system of selecting asphalt binders is focused on selecting the proper asphalt binder grade for the climate in which the asphalt binder is to be utilized. The specification parameters such as binder stiffness are constant for all asphalt grades, but the temperature at which the required parameters must be met are different for different grades of asphalt binders. The grade of asphalt binder is selected based on the anticipated high and low temperatures for the project location.

The PG binder specification represents a significant change in the way asphalt binders are specified and purchased by asphalt users. This system is a major improvement over the previously used Viscosity or Penetration based systems. Many state DOT's and local municipalities have adopted the PG binder specification system and refineries have rapidly moved to supply these binders.

Background

The intent of the SHRP program was to develop binder specifications that could be universally applied to all asphalt binders, regardless of the methods of manufacturing the binders and the additives and the modifiers used in the binder. Majority of the SHRP research was conducted with unmodified asphalt such as AC-10 or AC-20. These asphalts are also known as "neat" asphalt, since they don't contain additives or modifiers such as performance enhancing polymers. The test methods and associated binder specifications that were developed during SHRP program for neat asphalt were not verified for modified asphalts. Lack of verification was due to lack of time and available funds during the SHRP program. As a result, the PG binder grading system does not correctly characterize asphalts with polymer modifiers with proven field performance. There are currently several national research efforts in progress to address this deficiency in the PG system. The current research efforts are evaluating the PG system as it relates to commonly used polymer modifiers. As an interim measure, many polymer suppliers have identified additional tests to add to the battery of tests conducted in PG grading system or modifications to test protocols in order to characterize the polymer modified binders. This has resulted in grading systems commonly know as PG+ (PG- Plus), since additional tests or requirements plus the standard PG system are specified for polymer modified binders. Many agencies have adopted PG+ specification until the standard PG system is developed to accommodate all binder types.

Asphalt binders modified by addition of high percentages of crumb rubber have been utilized with proven field performance for several decades. The PG binder grading system due to some of the requirements of its testing system is not capable of correctly characterizing Asphalt-Rubber binder performance potentials. One main draw back of the PG system, as it relates to Asphalt-Rubber is the configuration of the Dynamic Shear Rheometer (DSR) test. The current gap setting between the upper and lower test platens is too small to accommodate crumb rubber particles.

Objectives and Scope

The objective of this project is to evaluate available information, test results and research work which have been conducted to characterize Asphalt-Rubber binders in PG system. This available information needs to be supplemented with additional laboratory work to develop a PG+ grading system for use with Asphalt-Rubber binders.

Work Plan

Task 1 - Literature Search

Research conducted by NCHRP, Western Research Institute, University of Nevada-Reno, Asphalt Institute or others as related to characterization of Asphalt-Rubber with PG tests will be reviewed.

Task 2 - Conduct Laboratory tests

Based on the information gathered in Task 1, identify gaps in the data and devise a laboratory testing plan to fill the gaps. Use a limited number of Asphalt-Rubber binders to conduct the required tests.

Task 3 - Develop PG+ Specifications

Prepare test protocols for new tests or revised protocols for existing tests, which need to be modified for use with Asphalt-Rubber binders. PG+ specifications will be developed specifically for Asphalt-Rubber.

Duration

12 to 18 months.

Estimated Costs

$125,000-$150,000

Products

A PG+ specifications for Asphalt-Rubber and applicable test protocols in AASHTO format.

Potential Partners

State highway agencies of AZ, CA, TX and other selected highway agencies, FHWA, University of Nevada-Reno, Western Research Institute, and Clemson University.

PROJECT 3

DOCUMENT MERITS OF ASPHALT RUBBER PRODUCTS

Introduction

Rehabilitation of existing pavements is a high priority among local, state and federal transportation agencies. This will continue to be of vital importance for many years. A few states and local agencies recognize that a cost-effective method for rehabilitation involves an appropriate use of Asphalt-Rubber in pavements.

Utilization of Asphalt-Rubber in pavement construction has been fragmented, and the technical merits for using Asphalt-Rubber products are not generally understood. The continued emphasis on recycling and reported good performance by some states warrants a factual, yet succinct, documentation of the technical merits of Asphalt-Rubber products for construction and maintenance activities.

Background

HMA pavements continue to be the most common type of pavement in the United States. Many pavements are reaching the end of their service life and will require rehabilitation to restore or improve the structural adequacy and to improve surface characteristics of the pavement (safety and smoothness).

Rehabilitation of HMA and PCC pavements must begin with an evaluation of the existing pavement condition, including the structural adequacy of the pavement. A systematic investigation of the pavement prior to repair and overlay will reveal problem areas and focus attention to the requirements of a suitable repair strategy (i.e. improves ride, mitigate reflection cracking, provide a safe riding surface, defer major rehabilitation, etc.). If the technical merits of Asphalt-Rubber products were properly documented, engineers could use this information for their rehabilitation and new construction strategies. The following topics must be covered:

- ?? **Types of Asphalt-Rubber applications**
- ?? **Types of pavement distresses**
- ?? **Correct application of Asphalt Rubber mixtures depending on traffic, climate and pavement distresses**

Objectives and Scope

The objective of this project is to document the technical merits of Asphalt-Rubber in HMA and spray applied applications for both rehabilitation and new pavement construction; and to define good practices for selecting proper treatment alternatives for the owner and contractor.

Work Plan

Task 1 - State-of-the-Practice Report

Document the state-of-the-practice for utilization of Asphalt-Rubber for both new construction and rehabilitation. Among the topics to be considered (but not limited to) are:

- ?? **Noise**
- ?? **Life/durability**
- ?? **Cost effectiveness**
- ?? **Friction**
- ?? **Smoothness**
- ?? **Structural design**
- ?? **Fatigue Life**
- ?? **Low temperature cracking**
- ?? **Reflective cracking**
- ?? **Mix Design**
- ?? **Recycling**
- ?? **Maintenance costs**
- ?? **Rehabilitation of PCCP**
- ?? **Climate and traffic conditions**
- ?? **Life cycle costs.**

Task 2 - Executive Summary

Develop a short document describing technical merits of Asphalt-Rubber products to provide guidance to the engineering and construction community.

Duration

Twelve Months

Estimated Cost

$25,000-$35,000

Product

A document which:

1. **Details the technical merits of Asphalt-Rubber products , and**
2. **Description of suitable applications of Asphalt-Rubber products**

Potential Partners

Caltrans, ADOT, TXDOT, AASHTO, FHWA, University of Nevada.

PROJECT 4

PERFORMANCE EVALUATIONS FOR ASPHALT-RUBBER PRODUCTS

Introduction

Documentation of pavement performance of Asphalt-Rubber mixtures and spray applications has been inadequate, thus making it difficult to characterize for engineers and administrators the merits of Asphalt-Rubber. A few states maintain an evaluation process for their Asphalt-Rubber pavements; however, this information traditionally can only be used by those states.

Information for application of Asphalt-Rubber needs to be obtained, analyzed, and reported for different regions of the country and for different engineering application (i.e. traffic volumes, mitigation of reflection cracking, overlays, new construction etc.) This information should be formatted in a usable manner to allow an engineer to recognize and predict Asphalt-Rubber HMA and Asphalt-Rubber binder properties with time under different pavement conditions. In addition, life cycle costs of Asphalt-Rubber paving products need to be determined.

Background

Information relative to the performance of pavements with Asphalt-Rubber HMA has not been available from public agencies. Pavement management systems generally do not contain sufficient information to define performance information for HMA mixture containing asphalt cement binders, much less those containing Asphalt-Rubber binders. Additionally experienced personnel frequently change position, and pavement life studies continuity remains an issue.

States with established pavement management systems and special pavement study sections have data that if properly recovered and analyzed could provide pavement life information. Detailed construction, rehabilitation, maintenance information and maintenance costs needs to be collected for Asphalt-Rubber activities. These data need to be reduced to a useful format for inclusion in life cycle cost analysis by engineers and administrators.

Objectives and Scope

The objective of this project is to define the performance of asphalt rubber HMA and spray applied rubber products for new construction, rehabilitation and maintenance requirements.

Work Plan

Task 1 - Review Published Information

Information from the published literature and internal public agency reports will be reviewed and summarized. It is anticipated that public agencies (state and local) will have to be contacted on an individual basis to obtain this information.

Task 2 - Public Agency Visits

State Highway Agencies in the following six states are to be visited TX, CA, FL, AZ, TN, and NV and City of Phoenix. Two-to-three day visits with follow up contact will likely be required to obtain accurate pavement life information. Data from pavement management systems and special studies will be of interest.

Task 3 - Summary Document

Prepare a summary of the pavement life information, including mean and variability information for pavement life for both new and rehabilitated pavements. Emphasis is needed on materials and construction activities, including blending and quality control for construction.

Duration

Twelve Months

Estimated Cost

$50,000-$75,000

Product

A document which summarizes the performance of asphalt products (i.e. chip seals, SAM, SAMI, Gap and Open graded Hot Mix). The format should be such that each agency can compare asphalt rubber products to other strategies.

Potential Partners

State highway agencies of TX, CA, FL, AZ, TN and NV, City of Phoenix FHWA and State Asphalt Pavement Associations, and Contractors used by the public agencies contacted.

PROJECT 5

INDIVIDUAL TECHNICAL MERIT DOCUMENTS

Introduction

A few states and local agencies have developed (from their own experiences) an adequate understanding of the technical merits of Asphalt-Rubber to justify the usage of the products. States or local agencies without these experiences cannot easily justify the usage of Asphalt-Rubber because of the increased initial cost associated with asphalt rubber. Information from states using Asphalt-Rubber could be of vital importance to states and local agencies, which may be considering the usage of Asphalt-Rubber in their pavement construction, rehabilitation, and maintenance programs.

Background

Information exists within a few states, which clearly documents the advantages (technical merits) of Asphalt-Rubber products. Data, which are available from these states, if characterized in engineering terminology, could be used to publicize the technical merits of Asphalt-Rubber products.

A systematic review of these current data which describes the technical merits of Asphalt-Rubber products is needed. This review should be short term and deal only with non-refutable conclusions of existing activities.

Objectives and Scope

The objective of this project is to develop technical merit information to be used by those considering the utilization of Asphalt-Rubber.

Work Plan

Task 1 - Conduct Agency Review

Acquire technical data and other pertinent information from select states, primarily CA, AZ, TX, and FL and local agencies relative to their usage of Asphalt-Rubber products.

Task 2 - Document Review of Data

Document Task 1 by summarizing the data from the states which currently recognize the benefits of Asphalt-Rubber construction; and document other current published information relative to the merits of Asphalt-Rubber construction activities.

Task 3 - Individual Merit Documents
Develop individual merit documents for the following:

- **Noise reduction**
- **Maintenance cost**
- **Performance of**
  1. **SAM and SAMI**
  2. **HMA construction, both OGFC and Gap Graded mixes**
  3. **PCCP Overlays**
- **Pavement smoothness (Ride)**
- **Life Cycle Cost Comparisons**

Duration
Twelve months.

Estimated Cost
$20,000-$30,000

Product

A series of engineering documents which summarize current activities by states and local agencies which use Asphalt-Rubber products. The thrust of these documents is to characterize non-refutable technical merits of asphalt products.

Potential Partners
Select state DOT's and local agencies, FHWA and contractors.
(Note: This is a short-term project, which can be accomplished with assistance from the TAB. It is different from Project 3, in that Project 3 is providing state-of-the-practice reports.)

PROJECT 6

ASPHALT-RUBBER FOR AIRPORT APPLICATIONS

Introduction

Asphalt rubber has been effectively used in many military, general aviation and regional airports through out the country. The use of Asphalt-Rubber as Stress Absorbing Membrane Interlayer (SAMI) or in Hot Mix Asphalt can provide improved performance for both runways and taxiways. In many local airports where airplane traffic is limited to small personal planes, Asphalt-Rubber seal coats can provide the resistance to oxidation and cracking which is the primary mode of failure in this low traffic application.

Background

Asphalt-Rubber due to its inherent ductility and flexibility is a unique paving product which can improve performance of flexible pavements in both highway and airfield applications. The improved ductility and resulting resistance to oxidative aging and cracking have been utilized in many airfield applications. Timely and appropriate maintenance and rehabilitation activities are important assuring longevity of small and large airports in. Asphalt rubber products such as Open Graded Friction Course, Asphalt-Rubber Hot mix and SAMI's due to their inherent flexibility can be an effective tool in ensuring pavement performance. This characteristic is especially important in small general aviation airports where the major cause of failures is deterioration associated with oxidative aging and cracking.

Objectives and Scope

The objective of this project is to develop a document focusing on application of Asphalt-Rubber SAM, SAMI or hot mix in airport projects. The document covers suitable applications in various aspects of local, regional or military airfields. The document will include photos of completed airport projects and will include a listing of some of the airports around the country, which have utilized Asphalt-Rubber.

Work Plan

Task 1 - Literature Review

Review existing literature and interview knowledgeable individuals to gather information about application of Asphalt-Rubber in airport projects.

Task 2 - List of Existing Projects

A listing of some of the airports around the country that have utilized Asphalt-Rubber will be prepared.

Task 3 - Prepare Focus Document
A document will be prepared to document the benefits of Asphalt-Rubber in airport projects. This document will be suitable to serve as background information for marketing.

Duration
Twelve months.

Estimated Cost
$25,000-$35,000

Products
Focus document on uses of Asphalt-Rubber in airport projects.

Potential Partners
FAA, U.S. Department of Defense and selected airport authorities (based on results of Task 1).

PROJECT 7

COMPARISON OF TECHNICAL MERITS OF ASPHALT-RUBBER AND TERMINAL BLEND PRODUCTS

Introduction

Traditional Asphalt-Rubber binders meeting the requirements of ASTM D8-88 have a long history of successful application as interlayer (SAMI), chip seal (SAM) and in hot mix. The unique characteristics of traditional Asphalt-Rubber such as its elasticity and resistance to oxidative aging are attributed to the high percentage of crumb rubber in the binder. The high percentage of crumb rubber in Asphalt-Rubber binder makes it necessary to blend the crumb rubber and asphalt on site prior to use to prevent settlement of crumb rubber from the binder and degradation of its properties.

Recent advances in blending polymers and other solid particles in asphalt has made it possible to blend small percentages of crumb rubber with asphalt at the asphalt terminal. The percentage of crumb rubber utilized in terminal blends is significantly lower than the percentage used in traditional Asphalt-Rubber.

Background

Extensive field experience and both full scale and laboratory research have established Asphalt-Rubber as a unique product to enhance the longevity of flexible pavements. Research by California Department of Transportation has led Caltrans to reduce overlay thickness requirements when Asphalt-Rubber is used in lieu of conventional dense graded asphalt concrete. Terminal blend rubberized asphalt is being offered as an equal alternate to Asphalt-Rubber. However, there is little documented evidence that terminal blend rubberized asphalt will offer the same resistance to rutting, fatigue cracking, thermal cracking, reflective cracking and oxidative aging that is a characteristic of Asphalt-Rubber.

Research is needed to quantify the rutting, fatigue cracking, thermal cracking, reflective cracking, and oxidative aging of both rubberized asphalt and the traditional Asphalt-Rubber.

Objectives and Scope

The primary objective of this research is to evaluate the performance of both terminal blend rubberized asphalt and the traditional Asphalt-Rubber with respect to rutting, fatigue cracking, thermal cracking, reflective cracking and oxidative aging. In addition a comparison should be made regarding the potentials of each system to utilize recycled tire rubber.

Work Plan

Task 1 - Literature Search
Existing literature and other available information will be evaluated to determine the extent of available information and gaps in data that must be filled.

Task 2 - Experiment Design
A comprehensive and statistical experiment design will be developed to compare the merits of mixtures composed of terminal blend rubberized asphalt and the traditional Asphalt-Rubber. The research plan will as a minimum consider resistance to rutting, fatigue cracking, thermal cracking, reflective cracking, and oxidative aging of both binders.

Task 3 - Conduct Experiments
After review of the experiment design and its approval by project review panel, the research will be conducted to complete the required experiments. All materials used in research project will be from actual projects that have been constructed with terminal blend and traditional Asphalt-Rubber.

Task 4 - Testing Protocol
Develop a testing plan for use by public agencies such that they can determine the technical merits of competing rubberized asphalt products. All test protocols and evaluation methods will be prepared in AASHTO standard format.

Task 5 - Final Report
A comprehensive final report will be prepared to include all relevant data and conclusions.

Duration
Twenty-four Months

Estimated Cost
$200,000-$300,000

Products

Document the relative performance potential of terminal blend rubberized asphalt and the traditional Asphalt-Rubber. Also a testing protocol will be developed for use by public agencies to determine relative performance of competing products. Also, the cost of old tire disposal must be included.

Potential Partners
Selected asphalt terminal blenders, contractors, state highway agencies of CA, TX and AZ, FHWA, and County of Los Angeles.

PROJECT 8

DATABASE OF ASPHALT RUBBER PROJECTS

Introduction

Asphalt-Rubber has been used since the early 1970's in several states and for many different applications. The predominate use of asphalt rubber has been in Southwest and Southern states. Asphalt-Rubber has been successfully used in chip seal, interlayers, under overlays and in various hot mix applications. With increased popularity of Asphalt-Rubber products, many agencies will begin using the material. A comprehensive database of existing Asphalt-Rubber projects and their performance will be a great resource for new users and those who have used Asphalt-Rubber in the past. The database will need to include information about the performance of Asphalt-Rubber sections, cost data, pavement types, traffic data and other pertinent information required for evaluation of these projects. The primary use of the information contained in the database is to enable prediction of life cycle cost of various Asphalt-Rubber applications.

Background

Many successful Asphalt-Rubber projects have been built in the past three decades. These projects are in several states and under jurisdiction of state, county or city entities.

With the rapidly changing public sector and contracting industry work force there is a possibility that many of the existing asphalt rubber projects will perform satisfactorily for decades without either the owner agency or the contracting industry being aware of the characteristics of these projects.

Objectives and Scope

There is a need to develop and maintain a database of Asphalt-Rubber projects around the country and maintain sufficient data to be able to determine successful applications and isolate the causes of premature failures.

Work Plan

Task 1 - Feasibility Study

Conduct a brief study to determine feasibility of this project and extent of effort needed to carry out the objectives.

Task 2 - Database Design

Upon review of the results of Task 1, the project sponsors will determine if the project should continue or be terminated. If the project is to continue, a detailed design for the database will be presented to project review panel. The design will include the type of information to be collected from each project and the justification for collecting the information. A computerized database program will be developed.

Task 3 - Collect Data

Collect data and populate the database with selected number of projects authorized by the sponsors.

Duration

Twelve to Twenty-four Months (Upkeep an ongoing effort)

Estimated Cost

Phase 1-$10,000 -$15,000
Phase 2-$75,000-$100,000

Products

Computerized database with data from selected projects.

Potential Partners

To be determined after the completion of Task 1.

PROJECT 9

RELATIONSHIPS BETWEEN MATERIAL PROPERTIES AND PAVEMENT PERFORMANCE THROUGH ACCELERATED PAVEMENT TESTS (APT) AND LABORATORY TESTS.

Introduction

Majority of tests used in characterization of HMA mixtures are empirical tests. This shortcoming in the existing test methods will prevent direct comparison of competing materials and their influence on pavement performance. User agencies are continuously in search of better and more economical materials or processes in their task of building and maintaining their pavements. The task of selecting the most cost-effective pavement materials is difficult and time consuming without proper test procedure, which correlate to pavement performance. Therefore some user agencies are forced to keep using the same products even with less than satisfactory performance. In many cases, user agencies are persuaded to try new products without any proof of their potential performance.

APT offers an alternative methodology to relate material properties to performance. APT devices are generally capable of apply load levels and load configurations which are more representative of typical traffic streams. One disadvantage of APT is the cost associated with purchasing the test device and conducting the tests.

Background

Site conditions, construction parameters and binder and mixture properties affect pavement performance. Influence of binder and mixture properties on performance is best determined by laboratory test prior to construction of the pavement. Current test methods do not reliably predict potential performance of asphalt mixtures. There is need to identify tests that will predict mixture performance with regards to fatigue cracking, rutting, reflective cracking and thermal cracking. Due to limitations of laboratory testing devices and constraints of conducting lab tests in limited laboratory space, test specimens are often small, in order of 2-6 inch cylindrical specimens or small beams. Working with small specimens introduces boundary conditions far different than those experienced in a highway pavement under highway traffic. Therefore, laboratory test results are sometimes not good indicators of performance.

Objectives and Scope

Scope of this project is to develop test methods and relationships between binder properties, mixture properties and pavement performance.

Work Plan

Task 1 - Literature Review

Review current literature to select any available test methods, which can characterize performance properties of Asphalt-Rubber mixtures.

Task 2 - Develop New Test Methods

In absence of existing test methods develop new test (and/or evaluation) methods to characterize the following:

?? Fatigue Cracking
?? Thermal Cracking
?? Rutting
?? Reflective cracking
?? Elastic properties

Task 3 - Performance Models

Develop models to relate mixture and binder properties determined in Task 2 to pavement performance.

Duration

Five to ten years.

Estimated Cost

$1,000,000-$1,500,000

Products

New binder and mixture test methods to predict pavement performance.

Potential Partners

Selected highway agencies, NCAT, FHWA, and Clemson University.

PROJECT 10

EVALUATE ASPHALT-RUBBER USING THE TEST PROPOSED FOR AASHTO 2002 DESIGN GUIDE

Introduction

The current procedures for mixture design do not differentiate between different asphaltic concrete mixtures and their influence on overall structural integrity of the pavement. In other words, the same structural number is assigned to the hot mix layer regardless of the mixture type or the binder type used in the hot mix layer. This approach to pavement design is counterintuitive specially since field experience has demonstrated that properties such as fatigue life and rutting resistance are significantly influenced by mixture and binder type. There is a need for a mechanistic method of pavement design that established a link between material properties and pavement design.

Background

One of the tasks of the NCHRP, which is responsible for developing the AASHTO 2002-design guide, is to select an asphalt mixture property as input for the pavement design. In addition to selecting the mixture property, the AASHTO 2002 researchers are responsible for outlining the laboratory test procedure for measuring this property. When such a test method is developed, it will be possible to compare relative influence of competing materials on pavement performance. This will enable user agencies to select pavement materials based on the value that materials add to improved pavement performance.

Objectives and Scope

The objective of this project is to conduct sufficient tests with Asphalt-Rubber mixtures in order to evaluate applicability of new test to the Asphalt-Rubber mixture. If the new test is found to accurately characterize properties of Asphalt-Rubber mixtures then the precision and bias of the new test in determining performance of Asphalt-Rubber mixtures must be determined. In addition, due to unique characteristics of Asphalt-Rubber, some changes to the test procedure may be needed in order to properly characterize Asphalt-Rubber mixtures.

Work Plan

Task 1 - Literature Search

Review the data produced by AASHTO 2002 researchers to determine repeatability, precision and bias of the new test with conventional mixtures.

Task 2 - Develop Experiment Design
Develop an experiment design to measure properties of Asphalt-Rubber mixtures using the new test. The experiment design will address repeatability and precision of the new test with Asphalt-Rubber mixtures.

Task 3 - Conduct Laboratory Test
Laboratory tests will be conducted according to the experiment design developed in Task 2.

Task 4 - Prepare Final Report
Final report will contain a comprehensive presentation of test results, conclusions and an executive summary.

Duration
Twenty-four months

Estimated Cost
$200,000-$300,000

Products

Determination of applicability of new test to asphalt rubber mixtures. If the new test is found to accurately characterize asphalt rubber mixture performance, then the precision and bias of the new test for asphalt rubber mixtures will be determined.

Potential Partners
AASHTO, FHWA, state highway agencies of AZ, CA, TX and FL, and University of Nevada-Reno.

PROJECT 11

LABORATORY AND FIELD EVALUATION PROCEDURES

Introduction

State highway agencies and local agencies are inundated by requests to utilize new materials. While every agency attempts to optimize its highway construction program (performance vs. cost) only a few are organized and funded to appropriately evaluate new or promising materials. As a result many states rely on the experiences from other states for acceptance or rejection of these new materials. This specifically includes the utilization of Asphalt-Rubber in HMA.

States that methodically evaluate new materials depend on field test sections and complementary laboratory testing in determining performance of new products. Materials that successfully pass the scrutiny of these states are then allowed and specifications are developed from information obtained in the field and laboratory testing activities. Thus, the significance of any field test section and/or laboratory is of paramount importance to those promoting new materials, Asphalt-Rubber being no exception. Results obtained from field-testing and laboratory testing programs that are not properly designed can easily lead to improper conclusion by an agency.

Background

It is almost certain that any significant increase in the usage of Asphalt-Rubber will be the result of successful field and laboratory testing (at least to the liking of the agency engineers and administrator). The interest of both the agency and the Asphalt-Rubber industry can best be served if the field testing and laboratory programs are properly designed and executed. Construction of field test sections and the conduct of laboratory testing programs are generally expensive undertaking; thus it behooves everyone involved to do it properly.

Objectives and Scope

The objective of this project is to develop field and laboratory testing procedures for evaluating Asphalt-Rubber HMA design and construction (new and rehabilitation).

Work Plan

Task 1 - Field Test Procedures

Identify the engineering requirements for a properly designed field test section for HMA pavements.

Task 2 - Laboratory Test Procedures
Identify the engineering requirements for a properly designed laboratory-testing program.

Task 3 - Construction Practices
Identify the proper construction practices to be followed during construction of the field test section(s). Included here is the magnitude of variability associated with QC/QA testing that is allowable.

Task 4 - How-to-Manual
Prepare a how-to-manual for designing and evaluating field test sections and laboratory testing programs.

Duration
Six to eight months.

Cost Estimate
$25,000-$40,000

Product
A how-to-manual for designing and evaluating field test sections and laboratory test programs.

Potential Partners
Highway agencies of CA, FL, AZ, TX and NM, Universities, FHWA.

PROJECT 12

DEVELOP PERFORMANCE RELATED SPECIFICATIONS FOR ASPHALT-RUBBER BINDERS AND MIXES

INTRODUCTION

Specifications are often guide documents for construction of highway projects. A good specification will ensure selection of appropriate materials and construction techniques in order to meet the project needs. Performance based specifications, aim to require materials and mixture properties which directly influence performance. Performance based specifications for crumb rubber modified (CRM) binders and mixtures needs to be developed. Specifications thus developed should be closely connected to the Superpave binder and mixture specifications system. The specifications should be recognized nationally; and should be validated with CRM projects or APT testing.

Background

Even without a comprehensive CRM Binders and Mixture specification there are numerous examples to prove that properly designed CRM-HMA meets or exceeds the performance potential of conventional HMA. A performance based specification for CRM mixtures will ensure successful utilization of the product.

Objectives and Scope

The objective of this project is to develop a CRM Binders and Mixture specification using the results of Project 9.

Work Plan

Task 1 - Grading System for CRM Binders
Develop a Grading System for CRM Binders and outline testing procedures to be used to assess the properties of the CRM binders.

Task 2 - Identify Test for CRM Mixtures
Identify the most appropriate tests that can be used to evaluate the mechanical properties of CRM mixtures that can be related to field performance.

Task 3 - Performance-Based Specification
Develop a performance-based specification for CRM Binders and Mixtures.

Task 4 - Laboratory-Field Correlation
Correlate the properties of CRM Binders and mixtures to field performance (or APT predicted performance) to validate/modify the performance-based specification.

Task 5 - AASHTO Standards
Prepare necessary test protocols in accordance AASHTO format.

Duration
Three to five years.

Cost Estimate
$150,000-$200,000

Product
A performance - based specification for CRM Binders and Mixtures.

Potential Partners
Caltrans, ADOT, TXDOT, AASHTO, FHWA, University of Nevada-Reno.

PROJECT 13

MIXTURE DESIGN METHOD FOR STONE MATRIX ASPHALT RUBBER (RSMA)

Introduction

Stone Matrix Asphalt (SMA) is a specific type of hot mix that has been used in Europe with success. Over the last five years, SMA has been introduced in US and has gained popularity as a premium hot mix designed to resist rutting. Much state DOT's have begun using SMA in the Interstate Highway and other high traffic volume projects. With increasing traffic volumes on most Interstate Highways, especially in urban areas it is anticipated that use of SMA as the hot mix of choice for overlays and new construction will be increasing.

Background

SMA is a gap graded hot mix with high concentration of coarse aggregates. In designing SMA mixtures, the volume concentration of coarse aggregate is significantly larger than that of fine aggregates. This allows the rock-on-rock contact between coarse aggregates thereby increasing the load carrying capacity of the hot mix layer. The high concentration of coarse aggregates will cause a significant reduction in aggregate surface area. The reduced surface area will reduce the ability of the mixture to accept asphalt binder without allowing asphalt drain down. To eliminate asphalt drain down and the fat spots that are caused by asphalt drain down, fibers and modified binders are introduced in the mixture at significant costs.

SMA mixtures are very similar to gap graded Asphalt-Rubber mixtures. Current field experience with gap graded or open graded asphalt rubber mixtures has proven that asphalt drain down is not a problem when Asphalt-Rubber is used. It is therefore feasible to use Asphalt-Rubber in SMA mixtures and eliminate the need for fibers and reduce the need for mineral fillers as significant savings without negatively impacting SMA performance. In addition Asphalt Rubber can significantly improve performance with respect to aging and low temperature cracking.

Objectives and Scope

Objective of this project is to develop a mixture design procedure for SMA mixtures utilizing Asphalt-Rubber as the binder.

Work Plan

Task 1 - Experiment Design

Design a laboratory experiment to determine volumetric properties of several conventional SMA mixtures and develop the design procedure such that Asphalt-

Rubber can be used to replace the conventional binder, fiber and a portion of the mineral filler.

Task 2 - Drain Down Test
Determine the drain down of several SMA mixtures with conventional binder and fiber combinations and with asphalt rubber. In addition drain down properties must be evaluated in field.

Task 3 - Final Report
Prepare a comprehensive report to document the findings.

Duration
Eighteen Months

Cost Estimate
$150,000-$175,000

Products
Mixture design method that allows use of asphalt rubber in SMA mixtures.

Potential Partners
FHWA, NCAT and selected state highway agencies.

RESEARCH COMMISSIONED BY RPA

Life Cycle Costs for Asphalt-Rubber Paving Materials (1999)

R. Gary Hicks, PhD, P.E., Professor Emeritus
James R. Lundy, PhD, P.E. , Associate Professor
Department of Civil, Construction and Environmental Engineering
Oregon State University, Corvallis, Oregon

Jon A. Epps, PhD, P.E., Professor of Civil Engineering
University of Nevada, Reno, Nevada

Evaluation of Caltrans Modified Binder (MB) Specification (1999)

R.G. Hicks, PhD, P.E., Professor Emeritus
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Oregon State University, Corvallis Oregon

Jon A. Epps, PhD, P.E., Professor of Civil Engineering
University of Nevada, Reno, Reno, Nevada

Quality Control for Asphalt-Rubber Binders (2000)

R. Gary Hicks, PhD, P.E., Professor Emeritus
Department of Civil, Construction and Environmental Engineering
Oregon State University, Corvallis, Oregon

Jon A. Epps, PhD, P.E., Professor Emeritus
Department of Civil Engineering
University of Nevada, Reno, Nevada

Evaluation of Asphalt-Rubber Pavements in Texas (2001)

Maghsoud Tahmoressi, P.E., President
PaveTex Engineering and Testing, Inc.
Austin, Texas

Development of a Mechanistic Overlay Design Method for Asphalt-Rubber Hot Mixes (2001)

Jorge B. Sousa, PhD. President, Consulpav International, USA & Portugal
Richard N. Stubstad, P.E, Managing Director, Consulpav International, USA
Jorge Carvalho Pais, Professor of Engineering, University of Minho, Portugal

Influence of Aging on Fatigue Behavior on Asphalt-Rubber Hot Mix-Gap Graded (ARHM-GG) and Conventional Asphalt Concrete Dense Graded (CAC-DG (2001)

Lutfi Raad, PhD, Director of the Transportation Research Center
Institute of Northern Engineering, University of Alaska Fairbanks

Fairbanks, Alaska

The Arizona Asphalt-Project Review, Part 1, Evaluation of A-R Pavements Constructed Before 1992 (ongoing)

Gene R. Morris, P.E., Consulting Civil Engineer
Douglas C. Carlson, Rubber Pavements Association
Arizona Department of Transportation

COOPERATIVE RESEARCH

Asphalt-Rubber Design and Construction Guidelines

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Prepared for the Northern California Rubberized Asphalt Concrete Technology Center, Sacramento, California in cooperation with California Integrated Waste Management Board, Caltrans, Rubber Pavements Association and FHWA.

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