Report Topic:

Evaluation of Rubberized Slurry Seal Materials

CalRecycle

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NOTE: Subsequent to the preparation of this report, legislation (SB 63, Strickland) signed into law by Gov. Arnold Schwarzenegger eliminated the California Integrated Waste Management Board (CIWMB) and its six-member governing board effective Dec. 31, 2009.

CIWMB programs and oversight responsibilities were retained and reorganized, effective Jan. 1, 2010, and merged with the beverage container recycling program previously managed by the California Department of Conservation.

The new entity is known as the Department of Resources Recycling and Recovery (CalRecycle) and is part of the California Natural Resources Agency.

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Appendix F Slurry Seal Specifications

Section A INTRODUCTION

The California Integrated Waste Management Board (CIWMB) has been evaluating the possibility of including Rubberized Slurry Seal Materials in their Rubberized Asphalt Concrete (RAC) Grant Program (SB 1346). The purpose of the RAC Grant Program is to continue and enhance the promotion of markets for recycled-content products derived from waste tires generated in California and decrease the adverse environmental impacts created by unlawful disposal and stockpiling of waste tires.

Slurry seals were developed and used for the first time in Germany in the late 1920's. At that time, the product consisted of a mixture of very fine aggregates, asphalt binder, and water, and was mixed by introducing the components into a tank outfitted with an agitator. It proved to be a novel approach, a new and promising technique for maintaining road surfaces, and marked the beginning of slurry seal development. However, it was not until the 1960's, with the introduction of improved emulsifiers and continuous flow machines, that real interest was shown in the use of slurry seal as a maintenance treatment for a wide variety of applications: from residential driveways to public roads, highways, airport runways, parking lots, and a multitude of other paved surfaces.

Despite the widespread use of slurry seals and micro-surfacing in the recent years, current tests and design methods are primarily empirical and are not related to field performance. The current International Slurry Seal Association (ISSA) procedures for Slurry Seal Mix Design (A105) and Micro-surfacing (A143) and the corresponding American Society for Testing and Materials (ASTM) Standards D3910 and D6372 have their origin in the 1980's before the widespread use of micro-surfacing and the use of polymer modified emulsions in slurry seals.

Scrap tire rubber has been used in chip seals for asphalt pavements since the 1970s, in rubberized asphalt concrete (RAC) since the 1980s, and more recently in rubberized asphalt slurry seals. Several rubberized slurry seal products are available in the market

and have been widely used in Southern California, as well as in other areas throughout the United States.

A.1 SCOPE OF WORK

The CIWMB Tire Remediation and Engineering Branch staff in conjunction with their nominated consultant MACTEC Engineering and Consulting Inc were tasked with providing the board to review documents related to rubberized slurry seal products and performance, and identify some preliminary items needed for product evaluation of Rubberized Emulsion Aggregate Slurry (REAS). The tasks were identified to be completed in three (3) phases. The first two phases were initiated July 17th, 2006 and subsequent third phase was initiated October 19th, 2007.

Phase I of the project comprised of two components; the first targeted a comprehensive literature review to supplement the marketing testimonials received by the board (from third parties) and identify other rubberized emulsion products; the second part dealt with the development of a survey of industry and agencies using rubberized slurry seal in the Los Angeles area.

Phase II consisted of laboratory evaluation of slurry seals, to include Rubberized Emulsion Aggregate Slurry (REAS); Polymer Modified Slurry Seals, and Conventional Slurry Seals (CQM). Testing will enable evaluation of the respective slurry seal products outlined for compliance with "Greenbook" Standard Specifications for Public Works Construction (2006 Edition) and California Department of Transportation - Caltrans specifications. Trial mix designs were developed for all products and mixes were evaluated for compliance with Greenbook and Caltrans specifications. Slurry seals were also tested for relative friction resistance using the British pendulum device and for resistance to abrasion as performance indicators.

Phase III evaluated currently available commercial slurry seal products by tracking field performance of existing slurry seal projects of various ages from approximately 1 to 10 years from placement).The field performance targeted data was used to assist in evaluating the relative benefits of the various slurry products. New slurry seal projects were evaluated during construction to identify construction-related factors that could impact performance. Candidate California local government agencies were solicited for

participation for the field study. Four agencies elected to partner with the Board, these agencies were: The City of Chula Vista, Sacramento County, and Pleasant Hill.

Under this partnership, the agencies agreed to share performance information regarding their respective existing conventional and REAS projects in exchange for the Board funding a side by side conventional and REAS project located in each of the jurisdictions. These projects were conducted under an interagency agreement with the Board with oversight by MACTEC.

MACTEC personal were tasked to perform the following in order to coordinate the conventional slurry seal, polymer slurry seal and REAS projects:

1. Evaluate current specifications and identify the need for contract and specification changes/modifications
2. Address the required changes/modifications to the current specifications for the Agencies and provide technical support to implement the proposed changes/modifications
3. Identify and prepare the required testing equipment for pre-contraction, construction and post-construction evaluation of the test sections
4. Follow up with the construction schedules with Agencies and Contractors to provide the inspection services at the required time and with sufficient personnel and equipment.
5. Conduct any field and laboratory performance testing to document performance of the slurry materials, and
6. Record filed documentation related to the performance of the slurry projects

Sections were selected and pavement conditions were documented prior to the slurry seal application. Individual components and slurry seal mixes were sampled during construction and tested for compliance with project specifications.

A.2 ORGANIZATION OF REPORT

This report focuses on the state of the technology and best practices resulting from a detailed literature review, survey of agency practices, slurry seal products laboratory evaluation, and performance evaluation of in-service and new construction slurry sealed sections.

The report is organized as follows:

Section A	Report Introduction
Section B	Presents the results of a comprehensive review and synthesis of the literature.
Section C	Presents the results of Phase I: Telephone interviews and online survey of users/ customers.
Section D	Presents the results of Phase II: Laboratory evaluation of slurry seals.
Section E	Presents the results of Phase III: Field performance of in-place slurry seals over time: "Fast Track" Approach and Results of Phase IV: Field performance of new slurry seal projects.
Section F	Presents a summary of key conclusions and recommendations.

Appendix A	Literature Review
Appendix B	Agency-Industry Surveys
Appendix C	Survey Summaries
Appendix D	Pavement Condition Evaluation Photographs
Appendix E	Pavement Condition Evaluation Photographs
Appendix F	Slurry Seal Specifications

Section B LITERATURE REVIEW

A technical literature search and review was performed to supplement the marketing testimonials received by the board for a REAS type application, to identify slurry related emulsion products, including rubberized slurry products. This was essentially focused on those experienced with use of REAS materials, as well as other rubberized surface treatment activities potentially available throughout the United States. This chapter describes the approach and findings of the literature review, presents information on relevant patents and associated rubberized slurry seal material specifications.

B.1 SUMMARY OF LITERATURE REVIEW

The technical literature on this subject located a significant number of documents and reviewed by the team. Literature searches were conducted using search engines such as the Transportation Research Information System (TRIS, a bibliographic database funded by sponsors of the Transportation Research Board [TRB]) and the National Technical Information System (NTIS). The Rubber Pavements Association (RPA) website and library and the United States Patent and Trademark Office website were also included in the search.

Following is a list of the documents found, with abstracts available in Appendix-A:

1. United States Patent # 5,539,029. Asphalt emulsion-rubber paving composition
2. United States Patent # 5,180,428. In situ rejuvenation of aged and cracked asphalt pavement
3. United States Patent # 5,151,456. Emulsified sealant having a high solids content
4. United States Patent # 4,621,108. Gilsonite-asphalt emulsion composition
5. United States Patent # 4,609,696. Rubberized asphalt emulsion
6. United States Patent # 4,564,310. Resilient paving composition for playfields sports fields and recreation areas
7. United States Patent # 4,548,962. Rubberized asphaltic concrete composition

8. United States Patent # 4,193,816. Quick-setting bituminous emulsion compositions
9. United States Patent # 4,137,204. Cationic method for emulsifying asphalt-rubber paving material and a stable thixotropic emulsion of said material
10. United States Patent # 4,069,182. Elastomeric pavement repair composition
11. United States Patent # 4,041,712. Method for reducing water loss through soil by seepage
12. United States Patent # 4,021,393. Method and composition for surfacing and repairing broken pavements with an elastomeric material having improved flexing properties at freezing temperatures without any significant loss of viscosity at high application temperatures
13. United States Patent # 4,018,730. Method for emulsifying asphalt-rubber paving material and a stable thixotropic emulsion of said material
14. Alternative Reflection Crack Treatments Pulverization and Rubberized Slurry.
15. High-Tech Surface Treatments Aim at U.S.
16. Interim Report on National Experimental and Evaluation Program (NEEP) Project
17. No 10-Reducing Cracking in Bituminous Overlays.
18. International Slurry Seal Association 7th Annual Convention.
19. Pavement Preservation Fights for Respect.
20. Reducing Reflection Cracking in Bituminous Overlays Utilizing a Strain Relieving Interlayer of Rubberized Slurry.
21. The History, Development, and Performance of Asphalt Rubber at ADOT. Special Report. Final Report.
22. Asphalt Research Leads to Longer Road Life.
23. California Puts Foamed Asphalt to the Test.
24. Characteristics and Performance of Asphalt-Rubber Material Containing a Blend of Reclaim and Crumb Rubber.
25. Crumb Rubber Chip Seal East of Punkin Center. Final Report.
26. Delamination Surveys and Removal Procedures for Rubberized Asphalt Chip Seal (RACS) Bridge Deck Overlays.
27. Follow Up Report on Demonstration Project 1-10-76-526 "Evaluation of Overflex Pavements Test Sections" (53 Mo.).
28. Otta Seals and Gravseals as Low-Cost Surfacing Alternatives for Low-Volume Roads: Experiences in South Africa.
29. Polymers Add Performance to Asphalt Emulsions.
30. Program Pinpoints Best Alternatives for Cost-Effective Road Maintenance
31. Rubberized Asphalt -- Still Sound after 20 Years
32. South Dakota Chip Seal Coat Study

33. Squeegee Seal and Crumb Rubber Chip Seal, Sapinero-East. Final Report
34. Summary of Workshop Session on Surface Sealing--Denver, Colorado
35. The Effects of Increased Salt Usage on the Chloride Concentration in South Dakota Department of Transportation Bridges and Roads
36. The State-of-the-Practice in Colorado--Part I
37. Thin Treatments Extend Road Life and Budget
38. Microsurfacing with Natural Latex-Modified Asphalt Emulsion: A Field Evaluation Reflection Cracking in Bituminous Overlays

B.2 REAS PATENT

The following is a brief description and abstract of a REAS patent registered by Petrochem Manufacturing Inc. that was highlighted during the literature search. The complete patent description is available in Appendix A.

United States Patent	**5,539,029**
Burris	**July 23, 1996**

Asphalt emulsion-rubber paving composition

Abstract

A method of preparing an asphalt emulsion-rubber paving composition comprises combining an aqueous asphalt emulsion, water, latex rubber, minus 40 size rubber particles, and a thickening agent, mixing said materials at substantially ambient temperature to form a substantially homogeneous liquid composition, adding to said liquid composition between about 5 and about 15 pounds of aggregate per gallon of said gallon, and mixing the components at substantially ambient temperature to form such paving composition.

Inventors:	**Burris; Michael V.** (Oceanside, CA)
Appl. No.:	**08/389,623**
Filed:	**February 21, 1995**

Current U.S. Class:	**524/60** ; 521/41; 521/44.5; 521/45; 524/59; 524/71
Current International Class:	C08L 95/00 (20060101)
Field of Search:	521/40,40.5,41,45,44.5 524/59,60,61,71

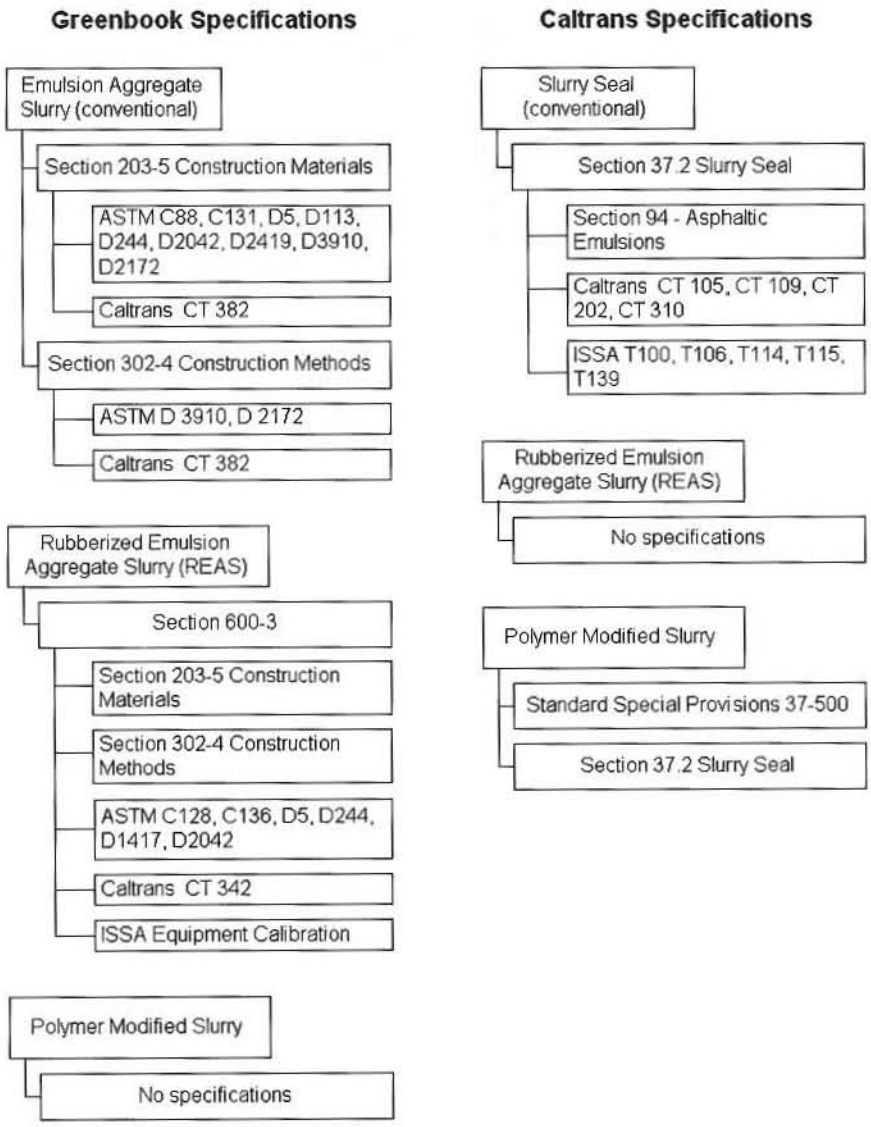
Word Mark	**FLEX SEAL**
Goods and Services	IC 019. US 001 012 033 050. G & S: ASPHALT EMULSION COMPOSITION FOR SEALING PAVEMENT. FIRST USE: 19881109. FIRST USE IN COMMERCE: 19881109
Mark Drawing	(1) TYPED DRAWING

Code	
Design Search Code	
Serial Number	75574381
Filing Date	October 21, 1998
Current Filing Basis	1A
Original Filing Basis	1A
Published for Opposition	September 5, 2000
Registration Number	2407717
Registration Date	November 28, 2000
Owner	(REGISTRANT) Flex Products, Inc. CORPORATION NEVADA 5235 Avenida Encinas, Suite A Carlsbad CALIFORNIA 92008
Attorney of Record	Jerry R. Seiler
Disclaimer	NO CLAIM IS MADE TO THE EXCLUSIVE RIGHT TO USE "SEAL" APART FROM THE MARK AS SHOWN
Type of Mark	TRADEMARK
Register	PRINCIPAL
Live/Dead Indicator	LIVE

B.3 SPECIFICATIONS

The most commonly employed specifications in California include: Greenbook Sections 203-5 and 302-4 Emulsion-Aggregate Slurry, and 600-3 Rubberized Emulsion – Aggregate Slurry (REAS) and Caltrans Standard Specifications Section 37-2 Slurry Seal and Standard Special Provisions SSP 37-500 and SSP 37-855.

The following schematic identifies the respective test methods and specifications for Greenbook, Caltrans and National Standards in use at the time of the evaluation.



Other specifications employed by agencies and industry include the following International Slurry Seal Association (ISSA) and American Society for Testing and Materials (ASTM) Specifications:

1. ISSA A105 " Recommended Performance Guidelines for Emulsified Asphalt Slurry
2. Seal "ISSA TB 100 "Test Method for Wet-Track Abrasion of Slurry Seal"
3. ISSA TB 106 "Measurement of Slurry Seal Consistency
4. ISSA TB 109 "Test Method for Measurement of Excess Asphalt in Bituminous Mixes by Use of a Loaded-Wheel Tester"
5. ISSA TB 114 " Wet Stripping Test for Cured Slurry Seal Mixes"
6. ISSA TB 139 "Method of Classified Emulsified Asphalt, Aggregate Mixtures by Modified Cohesion Test Measurement of Set and Cure Characteristics"
7. ASTM D3910 "Standard Practices for Design, Testing, and Construction of Slurry Seal"
8. ASTM D244 "Standard Test Methods and Practices for Emulsified Asphalts"

Section C TELEPHONE INTERVIEWS AND ONLINE SURVEYS – Phase I

C.1 INTRODUCTION

MACTEC Engineering and Consulting Inc. conducted several focused surveys regarding the use of slurry seals in the Los Angeles area. This area included the following counties, with the total number of cities within each county noted within parenthesis.

1. Los Angeles (198)
2. San Bernardino (31)
3. Orange (60)
4. Riverside (93)
5. Ventura (23)

The selection of cities and counties included in this survey was defined based on the following criteria. All five county Public Works Departments were contacted. The cities contacted included all those with populations over or close to a hundred thousand inhabitants, as well as the ones included in the list of customers provided by Petrochem Manufacturing, Inc. In order to increase the sample number of the survey, some other cities within Los Angeles County were included in the survey. The purpose was to capture a representative sample population given the budget and time criteria for the survey.

The manufacturers contacted included the four (4) companies which provide rubberized slurry seal materials or similar products in the targeted area. The list of contractors was obtained from the International Slurry Seal Association (ISSA) and the Rubber Pavements Association (RPA) members lists.

Two surveys were designed and distributed between August 14 and August 31, 2006 to the following groups.

1. Agencies Users Survey - Cities and Counties within the targeted Area.
2. Industry User Survey - Contractors and Manufacturers.

The surveys were closed on September 12, 2006. The surveys were designed to identify key aspects of the use of slurry seal, as well as costs, limitations, concerns, and expectations that users had with these systems. The blank surveys can be found in Appendix B. The original responses to the surveys are summarized in Appendix C. The surveys are summarized in Survey Results later in this chapter.

The contents of this chapter, the conclusions, and recommendations, are based on the review of existing literature on slurry seal and the responses to questionnaires received from agencies, contractors, and manufacturers that use these systems.

Note

The Questionnaires were not designed to be analyzed using any particular analysis technique, but instead were intended to obtain a "snapshot" of existing practices. The results of the two surveys are from a very limited sample; therefore, the data is not to be considered irrefutable.

C.2 SURVEY PROCEDURES

Telephone interviews were performed for both Users and Industry surveys. The interviewer tried to directly contact the Engineer responsible for scheduling and evaluating maintenance activities for the subject cities and counties. For the contractors and manufactures, the target contact was the person directly involved in development, construction, or application of slurry seals. When direct communication was not possible, voice messages and e-mails were sent to inform and request the completion of the corresponding survey. Tables 1, 2, 3, and 4 list the users and customers contacted by experienced MACTEC pavement engineering personnel.

Table 1 - County list

Agency/Contractor	Person Completing Survey
Los Angeles County DPW	Brian Rickey
Los Angeles County a	Fred Rubin
Los Angeles County b	Rob Kubomoto
Los Angeles County c	Erik Updyke
Orange County	Pete Allen
Riverside County	Kelley Donovan
San Bernardino County	Mike Wickfield
Ventura County	Criss Hook

Table 2 - Producers contact list

Contractor/Producers	Person Completing Survey
International Surfacing Systems	Murl Butler
Petrochem Manufacturing Inc.	Tom Cheuvront
Roy Allan Slurry Seal	Lance Allan
SealMaster	Non participant ([1])

([1]) Initially indicated as a non-participant, later an incomplete survey was submitted

Table 3 - Contractors contact list

Contractor/Producers	Person Completing Survey
All-American Asphalt	Emith
American Asphalt South	Jeff Petty
Asphalt Pavement Association	Jim St. Martin
Bond Blacktop	Ed Dillon
California Pavement Maintenance	Gordon Rayner
California Pavement Maintenance	Mike Marchini
Doug Martin Contracting Company	Doug Martin
First American Construction	Dan Bohnett
G. Scott Asphalt	Mike Kelly
Pavement Coatings Co.	Van Duncan
Sudhakar Company	Steve Flinner
Valley Slurry Seal	Pat McNairy
Western Emulsions Inc.	Non Participant ([2])

([2]) Elected not to participate

Table 4 - City contact list

Agency/Contractor	Person Completing Survey
City of Agoura Hill	Robert Cortes
City of Alhambra	Mary Seink
City of Anaheim	Craig Allan
City of Arcadia	Pat Malloy / Markly Cabagge
City of Artesia	Carlos Alba
City of Avalon	Pastor Lopez / Keith Lefever
City of Azusa	James Makshanoff
City of Baldwin Park	Jim Davis/David Lopez
City of Bell	Luis Ramirez
City of Bell Gardens	John Oskoui
City of Bellflowers	Glen Heit
City of Buena Park	Nabil Henein / Geca Binger
City of Burbank	Bonnie Teaford
City of Calabasas	Elain Camia
City of Carson	Vic Rollinger / Denny Bacon
City of Cerritos	Rash Syed
City of Claremont	Vince Ramos
City of Compton	William Louis
City of Corona	Steve Enna
City of Costa Mesa	Ernesto Munoz
City of Covina	Leo Tolintino
City of Cudahy	Carlos Alvarado
City of Downey	Jimmy Bautist
City of El Monte	Kev Tcharkhoutian
City of Fontana	Ricardo Sandoval
City of Fullerton	J. Aswinderd
City of Garden Grove	Rey Valenzuela
City of Glendale	Dennis Ambayic
City of Huntington Beach	Jason J. Churchill
City of Inglewood	Goran Milunovic
City of Irvine	Kurk Street / Terrel Hartmen
City of La Palma	Ismile Noorbaksh
City of La Verne	L.D. Johnson
City of Laguna Niguel	Ken Montgomery
City of Long Beach	Ed Aldridge
City of Los Angeles	Richard Villacorta / Tony Duong

Agency/Contractor	Person Completing Survey
City of Mission Viejo	Mark Chagnon
City of Moreno Valley	Carlos Zamano / Jim Gaier
City of Murrieta	Mike Brooks
City of Newport Beach	Sean Crumby
City of Ontario	Gary Harms
City of Orange	John Loertscher
City of Oxnard	Kay Swenson
City of Palm Desert	Ryan Gayler
City of Placentia	Travis Hopkins / Cameron Paper
City of Rancho Cucamonga	William O'Neil/Jerry Dwer
City of Rialto	Emilio Ramirez
City of Riverside	Bryan Matthews/Ben Badsen/Jim Larry
City of San Bernardino a	Randy Kettel
City of San Bernardino b	Mark Lancaster
City of Ventura	Karen Whitehouse
City of San Clemente	Mark Somerville
City of Santa Ana	Leon Tabako
City of Simi Valley	Tim Nanson / Sara
City of Temecula	Brad Buron / Randy West
City of Thousand Oaks	Manuel Alvarez / Joe Bravo

The users/customers contacted were referred to the CIWMB-MACTEC website project portal that was established for participants to effectively and productively complete the required surveys (www.mactec.biz/ciwmb/survey)

A screen shot of the survey portal is represented in the following Figure 1, and the survey questionnaire forms are presented in Appendix B.

Figure 1 - Screen shot of the web based survey portal

Additionally, Erik Updyke (LA County Public Works) representing the Southern Rubberized Asphalt Concrete Technology Center (SRACTC) distributed the survey details via e-mail to the Asphalt Paving Association (APA) – REAS subcommittee group working on the Greenbook updates. Steve Olson, Chairman of the Industry Pavement Preservation Task Group, also distributed the survey within the Southern California membership.

The League of Cities (LOC) in cooperation with the CIWMB agreed to assist by distributing through their List SERVE e-mail member distribution list the parameters and request to complete the on-line survey. This list was directed to LOC designated public works contact. Copies of this distribution were requested by MACTEC but were not made available.

C.3 SURVEY FINDINGS

C.3.1 Agencies Survey

Of the sixty four (64) city and county employees contacted for the agency survey, the following twenty nine (29) agencies responded to the survey:

1. City of Anaheim
2. City of Arcadia
3. City of Buena Park
4. City of Carlsbad ([3])
5. City of Carson
6. City of Downey
7. City of Duarte
8. City of Garden Grove
9. City of Huntington Beach
10. City of Inglewood
11. City of La Palma
12. City of Laguna Hills
13. City of Laguna Niguel
14. City of Los Angeles
15. City of Murrieta
16. City of Oceanside ([3])
17. City of Ojai
18. City of Ontario
19. City of Palm Desert
20. City of Palmdale
21. City of Port Hueneme
22. City of Rancho Palos Verdes
23. City of San Bernardino
24. City of San Clemente
25. City of San Diego ([3])
26. City of Temecula
27. City of Vernon
28. Los Angeles County
29. Orange County

([3]) Several non-solicited cities participated and submitted information. The cities of Carlsbad, Oceanside, and San Diego located in San Diego County and outside our targeted Area, completed the survey. Their inputs were included in the data set and report.

Of the twenty nine (29) respondents, twenty six (26) are currently using slurry seals, and two (2) plan to use it in the future. The only city not using these treatments has experienced past failures due to high truck traffic, but has employed them in residential roads. Just one (1) city is not expecting to employ slurry seal as a street maintenance treatment, and another is undecided due to further deterioration of their streets and the need for more rehabilitative type treatments, such as asphalt concrete overlays.

Figures 2, 3, and 4 provide some characterization of the types of slurry seals being used, the types of streets to which they are applied, and the maintenance activities used on slurry sealed pavements.

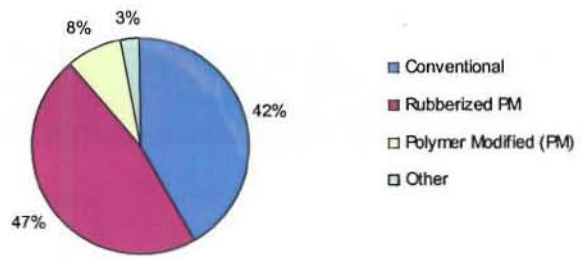


Figure 2 - Slurry seal materials application type

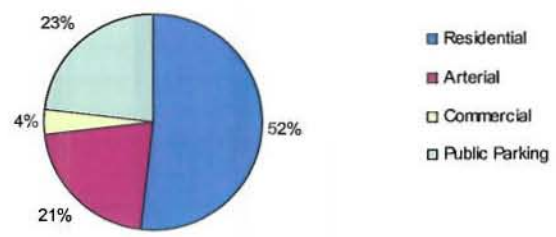


Figure 3 - Slurry seal materials application type

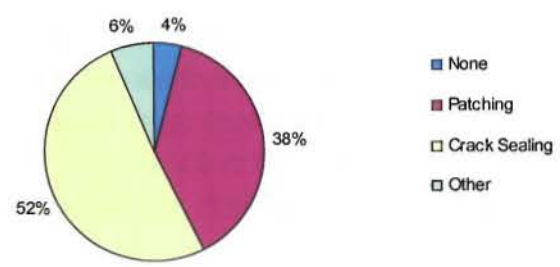


Figure 4 - Pavement applied Slurry seal maintenance activities

The average agency yearly usage (square yards, sq yd) is shown in Table 5 and Figure 5. In most cases, the square yards placed by the cities vary significantly not just between cities but also between years for the same city. The standard deviation varies from 46,000 to 927,000 square yards for conventional and rubberized slurry seals for the 4 years in analysis. The amount of data for Polymer modified and "Others" is too small to perform any analysis.

Table 5 - Quantities placed by slurry seal type and year

Slurry Seal Type	Year			
	2003	2004	2005	2006
Others			161,685	
Polymer Modified (PM)	3,700	3,600	3,300	125,333
Conventional	170,153	45,773	74,719	79,811
Rubberized PM	330,127	824,986	904,863	927,013

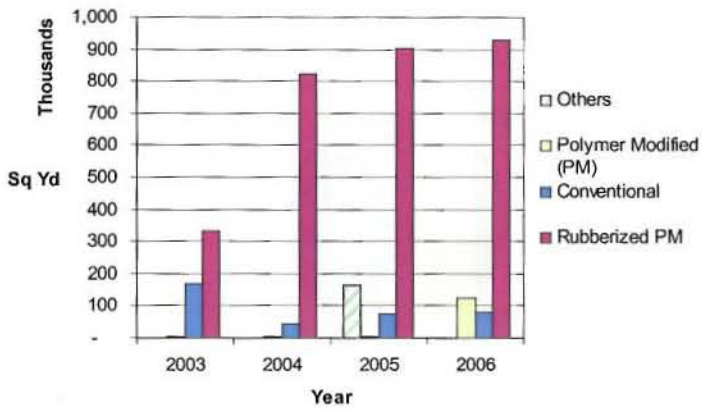


Figure 5 - Slurry seal quantities placed by type and year

The average unit prices for the different types of slurry seal materials are shown in Table 6 and Figure 6. Significant differences were observed in unit prices among the different cities. The standard deviations of unit prices were much smaller compared to the ones obtained from usage quantities, varying from 0.6 to 2.2 $/sq yd. The amount of data for Polymer modified slurry seals is too small to perform any further analysis and no unit prices were obtained for "Others".

Table 6 - Unit prices by slurry seal

Slurry Seal Type	Year		
	2004	2005	2006
Conventional	0.90	0.60	0.92
Polymer Modified (PM)	0.62	0.65	1.33
Rubberized PM	1.76	1.64	2.22

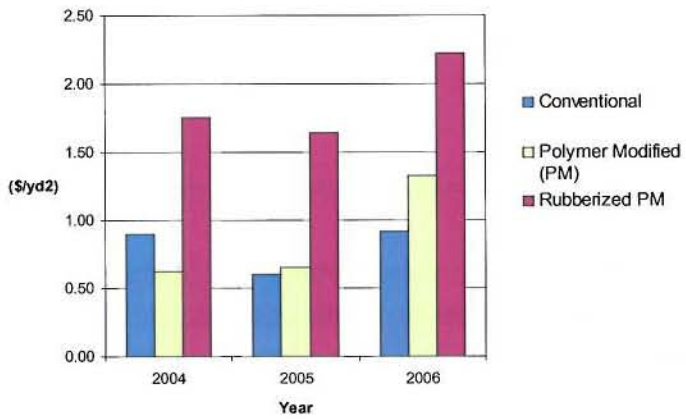


Figure 6 - Slurry seal Unit price by type and year

The average expected service life of slurry seals, and the respondents' expected, minimum, and maximum service lives for the different types of slurry seal are shown in Table 7 and Figure 7. The amount of data for Polymer modified slurry seal material was smaller, five (5) compared to that obtained for conventional and rubberized slurry seals (20 and 15, respectively). It is generally recognized by twenty two cities (22) that the service life of the treatment is affected by the condition of the underlying pavement surface prior to the application of the seal.

Table 7 - Service life by slurry seal type

Type	Expected (yrs)	Minimum	Maximum
Conventional	5.5	3.8	7.0
Rubberized PM	6.7	4.9	8.7
Polymer Modified (PM)	7.2	5.0	9.6

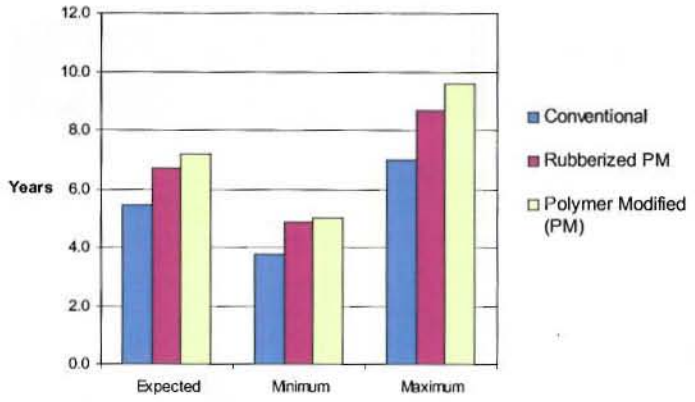


Figure 7 - Service life by slurry seal type

The performance ratings given to the different types of slurry seals are shown in Table 8. It is important to mention that the amount of data obtained for 'Polymer Modified' and 'Other' is significantly smaller than the one for Conventional and Rubberized Slurry Seals (7, 1, 21, and 21, respectively).

Table 8 - Performance ratings by slurry seal type

Type	Performance Ratings
Conventional	3.1
Rubberized PM	3.8
Polymer Modified (PM)	2.7
Others	1.0

The primary benefits cited for continuing the use of these systems is, in the order of frequency were:

1. Extend the pavement life
2. Cost effectiveness
3. Good performance
4. Aesthetic appearance

Various problems during construction and long-term performance identified are listed below, in the order of frequency:

During construction

1. Workmanship and Equipment
2. Production uniformity and compliance with specifications
3. Finish appearance (skid marks, overlaps, scuffing, etc.)
4. Color consistency

Performance related

1. Weathering
2. Crack reflection
3. Delamination
4. Oxidation (fading of color)

It should be noted that the most frequent short-term problems (during construction) are related to workmanship. Again, it appears that the skills of, or techniques used by, the construction crew are crucial to the success of the project. On the other hand, it is important to note that the most frequent long-term problems are reflective cracking and weathering. Reflective cracking distresses are most likely not related to the mix-design or construction process but rather the result of inappropriate project selection.

The last section on the agency questionnaire deals with quality assurance testing performed by the agencies. Twenty (20) agencies require submittal and approval of slurry seal mix designs prior to their use, eight (8) of them do not, and one (1) agency did not respond. It is important to mention that two (2) of the eight (8) agencies that do not require submittal and approval of the mix design have other mechanisms for controlling product quality. One agency provides the contractor with the mix design and the other uses within agency construction personnel.

Quality Assurance (QA) or acceptance testing of slurry seal materials and/or construction for evaluation of compliance with specifications is performed by sixteen (16) agencies. Most of them follow Greenbook specifications. Nine (9) cities do not employ any quality assurance or acceptance testing, except for visual observation during construction. Four (4) agencies did not respond to this question.

The most frequent tests performed by the agencies are Wet Track Abrasion Test (WTAT), and independent testing of the aggregate (gradation) and the emulsion prior to construction. Other tests included are asphalt and moisture content. Less frequent tests include: sand equivalent test and placement of a test strip before construction.

C.3.2 Industry Survey

From a total of eighteen (18) industry participants contacted, only five (5) responded to the survey. Those responding included the following:

1. Bond Blacktop
2. California Pavement Maintenance
3. Petrochem Manufacturing, Inc.
4. Doug Marting Contracting Co., Inc.
5. SealMaster

It is important to mention that the SealMaster survey was not completed entirely, reducing the number of answers for some of the questions. In most cases, the amount of data available from the industry survey is insufficient to provide a valid or statistically supported answer or value to the questions asked; this was the case for the quantities of slurry seal produced, and to a certain extent to the expected service life of these materials.

Another factor that should be taken into account is differences in consistency and components of the products included in the 'Others' category. Any result or analysis performed with these data should be thoroughly evaluated before any conclusions are made. The survey responses for this category can be found in Appendix C.

Of the five (5) industry participants that responded the survey, most produce more than one type of slurry seal material: four of them place conventional slurry seal materials, four (4) place rubberized slurry seals, four (4) place polymer modified slurry seals, and four (4) place other types of surface treatments. These included, rubberized emulsion, rubber polymer modified slurry, Micro-surfacing, and tire rubber modified cationic slurry seal.

Sources of mix designs for industry respondents varied. Three (3) employ private laboratories, another three (3) use designs developed by the emulsion provider, and three (3) others perform the designs in-house. The mix design procedures employed for conventional and polymer- modified slurry seals are, in most cases, the ISSA procedures. For rubberized slurry seals, Greenbook procedures and specifications are used. Design methods for 'Others' differ depending on the type of product used.

The quality control testing and evaluation of slurry seals follow the Greenbook and/or ASTM specifications for binders and aggregates, while the most widely used test is the Wet Track Abrasion Test.

The primary benefits or advantages cited for these systems are, in the order of frequency:

1. Extend the pavement life
2. Good performance
3. Cost effectiveness
4. Construction time

The major placing and environmental limitations identified are listed below, in the order of frequency:

1. Environmental conditions (temperature, rain, wind, etc.)
2. Traffic load
3. Pre-existing pavement condition

It is generally recognized within pavement engineering practice that the service life of the treatment is affected by the condition of the underlying pavement surface prior to the application of the seal. The respondents also recommend the following maintenance activities to pavements treated with slurry seals, in the order of frequency:

1. Patching
2. Crack sealing
3. Vegetation control

The average expected service life of slurry seals, the respondents' expected, minimum, and maximum service lives for the different types of slurry seal are shown in Table 9 & Figure 8.

Table 9 - Service life by slurry seal type

Type	Expected	Minimum	Maximum
Rubberized PM	5.8	4.3	7.7
Conventional	7.0	5.0	10.0
Polymer Modified (PM)	8.0	6.0	11.0
Others	8.3	6.0	11.7

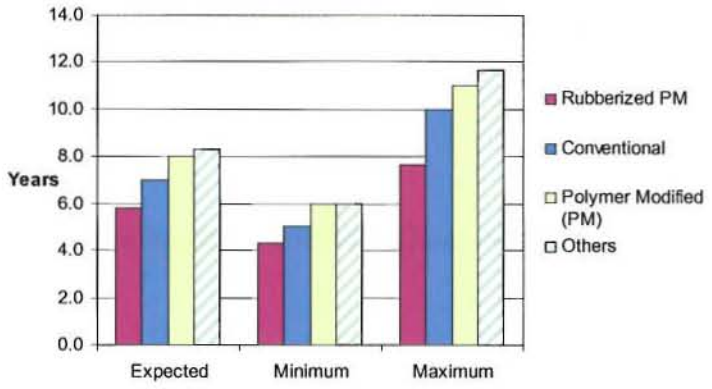


Figure 8 - Services life by slurry seal type

The average unit prices for the different types of slurry seal materials are shown in Table 10 and Figure 9. Relatively small differences were observed between the unit prices from the different contractors and producers; even though the amount of data obtained is small, the standard deviations are adequate, varying from 0.6 to 1.4. The exception is found on "Others" where the amount of data is too small (one value for 2004 and 2005, and two for 2006), additionally this category is accounting for very different materials with very different unit prices.

Table 10 - Unit prices by slurry seal type

Slurry Seal Type	Year		
	2004	2005	2006
Conventional	0.57	0.74	0.90
Polymer Modified (PM)	0.66	0.88	1.14
Rubberized PM	0.93	1.14	1.36
Others	2.00	2.25	1.93

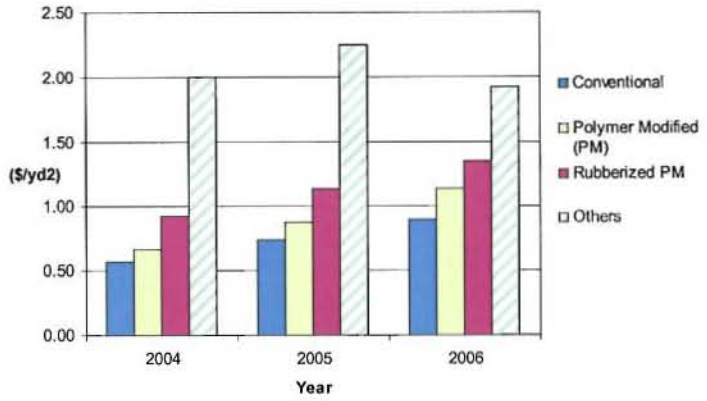


Figure 9 - Unit prices by slurry seal type

Section D LABORATORY EVALUATION OF SLURRY SEALS – Phase II

D.1 SCOPE OF WORK

The scope of work for Phase II consisted of the following laboratory evaluation of slurry seals:

1. Testing included three products: a Rubberized Emulsion Asphalt Slurry (REAS), a Polymer Modified Emulsion, and a Conventional Emulsion (CQS).
2. Samples of the candidate emulsified binders were obtained from the respective manufacturers or vendors and their compliance with Greenbook and ISSA specifications were verified.
3. Slurry Seal Mix designs were performed per Greenbook Sections 600-3 and 203.5. Three trial test specimens were prepared for each material mix design.
4. The three products were evaluated to identify possible differences in emulsion content and mix properties, and to verify compliance with Greenbook and ISSA specifications.
5. Slurry samples were evaluated for relative friction and resistance using the British pendulum device.

In addition to the laboratory testing described above, Petrochem Inc. and the City of Los Angeles (LA) provided samples of "Flexseal" a Rubberized Emulsion Aggregate Slurry (REAS) product formulated specifically for use in preventive maintenance applications within LA. Those two samples were also evaluated per Greenbook specifications to verify material compliance, and mix properties and performance.

The following lab tests were performed on all slurry seal products to verify compliance with Greenbook and ISSA specifications:

Aggregate Testing

1. Aggregate Gradation
2. Sand Equivalent (ASTM D 2419)

Emulsions

1. Spindle @ 10 RPM
2. Residue by Evaporation (ASTM D 244)
3. Sieve Test (% retained on No. 20 (850 µm)) (ASTM D 244)
4. Unit Weight (lbs/gal)
5. Penetration of Residue, 25°C, 100 g 5 sec. (ASTM D5)
6. Percent Residue Soluble in Trichloroethylene (ASTM D 2042)
7. Furol Viscosity at 25 C (77°F) (ASTM D 244)
8. Residue by Distillation (ASTM D 244)
9. Particle Charge (ASTM D 244)
10. Storage Stability; 1-day settlement (ASTM D 244)
11. Ductility of residue at 25C (77°F) (ASTM D 113)
12. Torsional Recovery, % (CT 332)

Slurry Seal Mix Design

1. Mix Time (TB 113)
2. Set time (TB 102 / D 3910)
3. Cure Time (TB 102 / D 3910)
4. Consistency (TB 106 / D 3910)
5. Consistency 7 hr cure, (TB 106 / D 3910)
6. Wet Cohesion (TB 139 / D 3910)
7. Wet Stripping (TB 114)

Performance Indicators Tests

1. WTA Loss 1 hr (TB 100 / D 3910)
2. WTA Loss 6 day (TB 100 / D 3910)
3. Loaded Wheel Test (TB 109)
4. British Pendulum Device (ASTM E 303-93)

D.2 LABORATORY MIX DESIGN EVALUATION

D.2.1 Rubberized Emulsion–Asphalt Slurry (REAS) Samples

Table 11 shows the test results for the Rubberized Emulsion-Asphalt Slurry (REAS) samples. Besides the results for the mix design evaluation (Trail 1, 2, and 3 values), two other samples were evaluated: a sample provided by Petrochem Manufacturing Inc (FlexSeal) and a sample from the City of Los Angeles. These two samples were obtained by the described agencies and shipped to MACTEC for testing. No material characterization is shown in table 11 for these samples, because no components samples were provided for characterization of the aggregate and emulsion.

Table 11 - REAS Type I Mix Design Data

	Greenbook /ISSA Requirements	Trial 1	Trial 2	Trial 3	Petrochem sample	City of LA Job Mix Formula
Aggregate Gradation						
# 4 (4.75 mm)	100		100			
# 8 (2.36 mm)	90-100		98			
# 16 (1.18 mm)	65-90		68			
# 30 (600 μm)	40-60		44			
# 50 (300 μm)	25-42		29			
# 100 (150 μm)	15-30		19			
# 200 (75 μm)	10-20		12.4			
Sand Equivalent (D 2419)	55 min		68			
Emulsion						
Spindle @ 10 RPM	2500-20000		6267			
Residue by Evaporation (ASTM D 244)	50 min		54.5			
Sieve Test (% retained on No. 20 (850 μm)) (ASTM D 244)	2.0 max		4.78			
Penetration of Residue (ASTM D5)	20-40		12			
Percent Residue Soluble in Trichloroethylene (ASTM D 2042)	75 min		81.79			
Composition						
Weight per Gallon (lbs/gal)	8.33-8.75	13.08	12.85	12.48	13.36	13.02
Mineral Aggregate (lbs Aggregate per gal RPME)		16	14	12		16
Mineral Admixture (% by weight of aggregate)		0.5	0.5	0.5		0.75
Set Control Additive (% by weight of aggregate)		N/A	N/A	N/A		
Mixing Water (% by weigh of agg)		11	10	9		13
Asphalt Emulsion (% by weight of aggregate)		52.9	60.5	70.7		52.9
Residual Asphalt (% by weight of aggregate)		28.8	33	38.5		28.8
	Greenbook	Trial 1	Trial 2	Trial 3	Petrochem	City of LA

	/ISSA Requirements				sample	Job Mix Formula
Mix Design Evaluation						
Mix Time (TB 113),	min 180 sec	>180	>180	>180	>180	>180
Set time (TB 102 / D 3910),	min 30 min	Pass	Pass	Pass	Pass	Pass
Cure Time (TB 102 / D 3910),	min 60 min	Pass	Pass	Pass	Fail	Pass
Consistency (TB 106 / D 3910),	20-40	24	28	25	20	32
Consistency 7 hr cure, (TB 106 / D 3910),	20-41					22
Wet Cohesion (TB 139 / D 3910)						
15 min cure		9	9	9		10
30 min cure,	min 12 kg-cm	10	10	10	10	11
60 min cure,	min 20 kg-cm	11	10	11	11	12
90 min		11	11	12	13	13
120 min		12	11	13	13	15
240 min		17	16	18	16	18
360 min					20	
Wet Stripping (TB 114)	min 90%	Pass	Pass	Pass	Pass	Pass
WTA Loss 1 hr (TB 100 / D 3910)	max 75 g/sf	47.5	37.7	26.7	36.1	37.5
WTA Loss 6 day (TB 100 / D 3910)		112.2	97.3	92.1	143.8	110.6
Loaded Wheel Test (TB 109)	max 50 g/sf	32.3	38.7	42.6	41	34.5
British Pendulum Devise (ASTM E 303-93), Average		84	83	78	83	84
3 BPN Readings		84,84,84	82,84,82	78,79,78	82, 84, 83	85, 83, 84
90 degree rotation, 3 BPN Readings		84,83,84	83,83,82	79,78,78	83, 83, 84	84, 84, 83

D.2.2 Polymer Modified Emulsion Samples

The following Table 12 shows the test results for the Polymer Modified Emulsion mix design evaluation.

Table 12 - Polymer Modified Emulsion Mix Design Data

	Greenbook /ISSA Requirements	Trial 2	Trial 3	Trial 4
Aggregate Gradation				
3/8" (9.5 mm)	100		100	
# 4 (4.75 mm)	90-100		99	
# 8 (2.36 mm)	65-90		86	
# 16 (1.18 mm)	45-70		65	
# 30 (600 μm)	30-50		49	
# 50 (300 μm)	18-36		35	
# 100 (150 μm)	10-24		23	
# 200 (75 μm)	5-15		14.4	
Sand Equivalent (D 2419)	55 min		58	
Emulsion				
Furol Viscosity at 25 C (77F) (ASTM D 244)	15-90		52	
Residue by Evaporation (ASTM D 244)	CT 33:157 min		64.2	
Residue by Distillation (ASTM D 244)				
Sieve Test (% retained on No. 20 (850 μm)) (ASTM D 244)	0.30 max		0.09	
Particle Charge (ASTM D 244)	Positive		positive	
Storage Stability; 1-day settlement (ASTM D 244)	1.0 max		0.85	
Penetration of Residue (ASTM D5)	40-90		53	
Ductility of residue at 25C (77F) (ASTM D 113)	400 min		1500+	
Torsional Recovery, %	18 min		33.4	
Composition				
Mineral Admixture (% by weight of agg)		N/A	N/A	N/A
Set Control Additive (% by weight of agg)		0.5	0.5	0.5
Mixing Water (% by weigh of agg)		10.5	9	7.5
Asphalt Emulsion (% by weight of agg)		12	14	16
Residual Asphalt (% by weight of agg)		7.7	8.99	10.27
Mix Design Evaluation				
Mix Time (TB 113),	min 180 sec	>180	>180	>180
Set time (TB 102 / D 3910),	min 30 min	Pass	Pass	Pass
Cure Time (TB 102 / D 3910),	min 60 min	Pass	Pass	Pass
Consistency (TB 106 / D 3910),	20-40	24	28	27
Wet Cohesion (TB 139 / D 3910)				
15 min cure		11	11	11
30 min cure,	min 12 kg-cm	14	15	14
60 min cure,	min 20 kg-cm	21	22	22
90 min		23	24	25
120 min		26	26	27
240 min		28	28	28
360 min				
Wet Stripping (TB 114)	min 90%	Pass	Pass	Pass
WTA Loss 1 hr (TB 100 / D 3910)	max 75 g/sf	30.6	23.4	19.8
WTA Loss 6 day (TB 100 / D 3910)		23.7	19.2	18
Loaded Wheel Test (TB 109)	max 50 g/sf		26.8	26.8
British Pendulum Device (ASTM E 303-93), Average			75	78
3 BPN Readings			75, 74, 75	78, 78, 77
90 degree rotation, 3 BPN Readings			75, 75, 75	79, 78, 78

D.2.3 Conventional CQS Emulsion Samples

Table 13 - Conventional (CQS) Emulsion Mix Design Data

	Greenbook /ISSA Requirements	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Aggregate Gradation						
3/8" (9.5 mm)	100	100				
# 4 (4.75 mm)	90-100	99				
# 8 (2.36 mm)	65-90	86				
# 16 (1.18 mm)	45-70	65				
# 30 (600 µm)	30-50	49				
# 50 (300 µm)	18-36	35				
# 100 (150 µm)	10-24	23				
# 200 (75 µm)	5-15	14.4				
Sand Equivalent (D 2419)		58				
Emulsion						
Furol Viscosity at 25 C (ASTM D 244)	15-100	36				
Residue by Distillation (ASTM D 244)	60 min	66.9				
Sieve Test (% retained on No. 20 (850 µm)) (ASTM D 244)	0.1 max	0.02				
Particle Charge (ASTM D 244)	positive	positive				
Storage Stability; 1-day settlement (ASTM D 244)	1.0 max	0.34				
Penetration of Residue (ASTM D5)	45-80	52				
Ductility of residue at 25C (ASTM D 113)	400 min	1500+				
Percent Residue Soluble in Trichloroethylene (ASTM D 2042)	97.5 min	99.86				
Composition						
Mineral Admixture (% by weight of agg)	min 180 sec	N/A	N/A	N/A	N/A	N/A
Set Control Additive (% by weight of agg)	min 30 min	0.5	0.5	0.5	0.5	0.5
Mixing Water (% by weigh of agg)	min 60 min	13	11.5	10.5	9.5	8.5
Asphalt Emulsion (% by weight of agg)	20-40	12	14	16	18	20
Residual Asphalt (% by weight of agg)		8.03	9.37	10.7	12.04	13.38
Mix Design Evaluation						
Mix Time (TB 113),		>180	>180	>180	>180	>180
Set time (TB 102 / D 3910),		Pass	Pass	Pass	Pass	Pass
Cure Time (TB 102 / D 3910),		Pass	Pass	Pass	Pass	Pass
Consistency (TB 106 / D 3910),		24	28	27	29	32
Wet Cohesion (TB 139 / D 3910)						
15 min cure		11	11	11		
30 min cure,	min 12 kg-cm	14	15	14		
60 min cure,	min 20 kg-cm	21	22	22		
90 min		23	24	25		
120 min		26	26	27		
240 min		28	28	28		
Wet Stripping (TB 114)	min 90%	Pass	Pass	Pass	Pass	Pass
WTA Loss 1 hr (TB 100 / D 3910)	max 75 g/sf	75.5	71.9	57.2	46.5	26.7
WTA Loss 6 day (TB 100 / D 3910)		40.3	32.5	28.6	26.8	19.8
Loaded Wheel Test (TB 109)	max 50 g/sf		30.8	33.9	35.5	38.7
British Pendulum Device (ASTM E 303-93), Average		Testing on target values obtained of the Design JMF16.5% CQS-1h			79	
3 BPN Readings					78, 79, 79	
90 degree rotation, 3 BPN Readings					79, 79, 80	

D.2.4 Findings

In general terms, all Slurry Seal materials comply with Specifications requirements except for all REAS samples when tested for wet cohesion and the Conventional (CQS) trial sample 2 when tested for wet track abrasion loss at 1 hour soak.

The CQS mix design evaluation shows excessive loss for the Wet Track abrasion test on trial sample 2. This loss is reduced and the minimum requirement is exceeded with all other trial samples by increasing the asphalt emulsion content of the slurry seal.

The REAS mix design evaluation shows insufficient wet cohesion test results for both the 30 minutes and the 60 minutes test periods. The International Slurry Surfacing Association (ISSA) A105 (May 2005) Recommended Performance Guidelines for Emulsified Asphalt Slurry Seal recommends a minimum wet cohesion 30 minutes value of 12 kg-cm and a minimum wet cohesion 60 minutes value of 20 kg-cm. The mix design evaluation, as well as the testing done on the slurry seal samples provided by Petrochem and the City of Los Angeles, show very low values for both wet cohesion time periods; insufficient to fulfill the ISSA mix design recommended values. All five (5) samples did not reach the recommended minimum 20 kg-cm torque level to allow traffic after 240 minutes of curing.

The REAS samples show a significantly higher loss for the Wet-Track abrasion six-day soak (Tables 11, 12, 13, and 14) in comparison with the CQS and the Polymer Modified Slurry Seals. The ISSA does not recommend maximum values for the six-day soak test for Slurry Seals, but does for micro-surfacing seals (75 g/ft^2). ISSA in their Technical Bulletin No. 100 (4th Revision 2005) describes the significance of the Wet Track Abrasion test as:

"The Wet Track Abrasion Test is a simulated performance test which has been correlated to the wearing qualities of the field applied slurry seals. The test establishes the minimum permissible emulsion content of a given system. System Classification of long term moisture susceptibility may be determined by use of the 6-day soak procedure"

These higher Wet-Track abrasion six-day soak values for the REAS samples may be indicators of a material with higher susceptibility to moisture damage resulting possibly from much weaker aggregate-binder cohesion in this system.

The system with the highest Wet Track abrasion one hour soak loss was the conventional (CQS) samples, but test results were still well below specification requirements. The polymer

modified emulsion shows the best performance of the three systems when evaluated for Wet-track abrasion for both one hour and six-day soak.

The British Pendulum Numbers obtained for all three systems are very similar; even though the REAS sample was prepared with a Type I gradation, as most of the agencies contacted reported using this type of gradation, meanwhile a Type II gradation was used for the Polymer Modified and the CQS slurry seals.

Despite the widespread use of slurry seals and micro-surfacing in the recent years, current tests and design methods are primarily empirical and are not related to field performance. The current International Slurry Seal Association (ISSA) procedures for Slurry Seal Mix Design (A105) and Micro-surfacing (A143) and the corresponding American Society for Testing and Materials (ASTM) Standards D3910 and D6372 have their origin in the 1980's before the widespread use of micro-surfacing and the use of polymer modified emulsions in slurry seals.(3-6)

Recognizing the need for more rational design methods for slurry seal and micro-surfacing, the Federal Highway Administration (FHWA) enlisted the California Department of Transportation (Caltrans) to form a pooled fund study with the overall objective of developing a rational mix design method for slurry seal and microsurfacing. The improved mix design procedures, guidelines, and specifications will address the performance needs of the owners and users, the design and application needs of the suppliers, and improve the reproducibility of the test methods used for the mix designs. While differences exist between slurry seal and micro-surfacing applications (i.e., traffic volume, application thickness, and curing mechanisms), the similarities of the tests currently used indicate that the two systems must be studied together.

The States that contributed to the pooled fund study are: California, Delaware, Georgia, Illinois, Kansas, Maine, Michigan, Minnesota, Missouri, New Hampshire, New York, North Dakota, Texas, and Vermont.

It was anticipated during this study and the pooled fund study that test methods and new protocols could be utilized and evaluated. Although both groups had mutual exchanges of research materials, the time lines of each representative study were not running on a beneficial stream. Information from the polled fund study final report is referenced within the conclusion and recommendation section of this report.

The overall goal of the pooled fund study is to improve the performance of slurry seal and micro-surfacing systems through the development of a rational mix design procedure, guidelines, and specifications.

Phase I of the project had two major components; the first consisted of a literature review and a survey of industry and agencies using slurry and micro-surfacing systems; the second part of Phase I dealt with the development of a detailed work plan for Phases II and III. The Phase I effort is complete and all findings were summarized in the Phase I Report.

In Phase II, the project team evaluated existing and potential new test methods, proposed a rational mix design procedure, conducted ruggedness tests on recommended equipment and procedures, and prepared the subject report that summarizes all the activities undertaken in Phase II.

In Phase III, the project team will develop guidelines and specifications, a training program, and provide expertise and oversight in the construction of pilot projects intended to validate the recommended design procedures and guidelines.

Caltrans has also conducted studies in the pavement preservation area in the determination of benefits of pavement preservation using city and county data in California.

This report presented the results of an analysis of data from local agency pavement management systems to document the benefits of performing pavement preservation verses pavements that receive no pavement preservation until they are rehabilitated, reconstructed, or replaced. The ultimate objective was to identify specific strategies that reduce the State Highway Operation and Protection Program (SHOPP) by delaying the need for rehabilitation, reconstruction, or replacement when using pavement preservation strategies. The scope of the project included:

1. Gathering treatment performance and cost information from local agencies in the state of California.
2. Determine and quantify the treatment life as a result of using various pavement preservation strategies.
3. Conduct life cycle cost analysis and appropriate cost evaluation to determine the cost benefits for various strategies and to identify the most effective strategies that delay the need for rehabilitation, reconstruction and replacement.

Conclusions from this study have been included at the end of this report in Section F.

Section E FIELD PERFORMANCE OF IN-PLACE SLURRY SEALS Phase III

E.1 FIELD PERFORMANCE CONSIDERATIONS

Field performance evaluation of paving materials presents some complex problems due to the number of factors related to variability of materials, mix design, production and placement that may affect performance. One major issue is the length of time required to obtain useful results. Service life for a slurry seal application depends on a number of factors, including but not limited to:

1. The type and volume of traffic using it - low volume residential, commercial, and arterial.
2. The condition of the pavement on which it was placed.
3. Prevailing climate - range of temperatures, amount of rainfall.
4. Quality of materials and design - including aggregate gradation.
5. Quality of application and workmanship.

Estimates of expected service life may vary from 1 to 10 years depending on those factors, but a range of 3 to 5 years are considered typical. Obviously a study of this duration was prohibitive; therefore the study adopted two complementary approaches for evaluating field performance:

The **"Fast Track Approach"** – Evaluate existing slurry seal projects of various ages was used as the quickest way to provide some assessment of slurry seal performance over time, by identifying existing slurry seal projects of various ages (approximately 1 to 10 years) that use the materials of interest: rubberized polymer-modified, polymer-modified, and conventional asphalt emulsions.

The **"New Project Approach"** for new slurry seal project field performance of in-place slurry seals, and field performance".

E.2 PAVEMENT MANAGEMENT REQUIREMENTS AND LIMITATIONS

An adequate pavement construction and maintenance history is required to understand how the pavement has performed over time and to study the life of a specific treatment. Service life of the treatment can be highly influenced by the quality of pavement construction and maintenance. All treatments applied to a pavement section should be recorded to allow for analysis of the pavement performance and the benefits of the pavement treatment.

Due in part to the limited resources to implement pavement management systems, it was found that the pavement management systems used by the participating city and county have relatively short history of data. In both cases, records were limited to the original construction date of the sections and the construction date of the slurry seal treatment under evaluation.

For pavement construction and maintenance history, a comprehensive pavement inspection program can be highly beneficial for the evaluation of pavement performance and the benefits of the pavement treatment. A good pavement inspection program provides the needed information on pavement performance history and allows an easier evaluation of the treatment performance.

The amount of PCI information found in the databases used by the participating city and county contained no pavement condition data before the application of the slurry seal treatments and only one PCI evaluation was documented in the pavement management reports provided. Due to this limitation, it was not possible to determine the pre-existing road condition before the application of the slurry seal; making the evaluation and comparison of the different slurry seal treatments more difficult.

In order to evaluate and quantify the behavior and performance of the different slurry seal treatments, and in addition to the PCI visual inspections, also performed an evaluation of these sections focusing only on the weathering deterioration of the slurry seal, independent of the overall pavement condition. Affected areas and severity levels for this distress were quantified and compared in this analysis.

Initial consideration was to classify projects based on traffic volume, but information provided was insufficient or not up-to-date.

E.3 "FAST TRACK APPROACH" – SITE CONSIDERATIONS

This approach included the following activities:

Coordination with agencies (Cities and Counties) were carried out to identify candidate slurry seal projects of various ages from 1 to 10 years for which design and construction records are available for correlation with observed performance. These types of records are essential to identify the materials used. This proved difficult in finding detailed records for projects that are more than five (5) years old.

Based on available information, MACTEC tried to classified projects according to the following parameters:

1. Type of slurry seal material
2. Treatment age
3. Roadway type (residential, collector, commercial, arterial)
4. Traffic volume in terms of average daily traffic (ADT) with % trucks or ESALs, or as traffic index (TI). ADT ranges of interest are: 0 to 1,000; 1,001 to 5,000; and 5,001 to 10,000
5. Aggregate gradation
6. Weather conditions

For projects in southern California, weather is generally expected to be relatively temperate with limited rainfall. Climate effects would be expected to be more important in areas with freeze-thaw or higher rainfall, such as Sacramento.

Twelve (12) rubberized emulsion-asphalt slurry (REAS) projects were indentified in the City of Chula Vista, CA and sixteen (16) conventional Cationic Quick Setting emulsion (CQS) slurry seal projects in Sacramento County. Due to the limitation of having just two agencies, two different slurry seal products, and two very different weather conditions, a factorial type evaluation of the existing projects was not developed. Although, this exercise provides a comparison of performance for the two products evaluated.

Randomly selected sections from each project and conducted distress surveys of the respective slurry seal surfaces according to the established methods of MicroPAVER. MicroPAVER has been adopted by the American Public Works Association (APWA) as a standard for pavement condition evaluation and pavement management systems. The results were used to calculate a pavement condition index (PCI) for each project. Repeated

surveys over time, not included in this analysis, would provide additional performance data over the life of the respective slurry seal projects.

Pavement condition index (PCI) is a numerical value calculated using distress data collected during a visual condition survey which includes various distress types, severity levels, and amount or density of the distress. This index evaluates the pavement's structural integrity and the surface condition. Some of the distresses identified in the visual inspection for asphalt concrete pavements include: alligator cracking, block cracking, longitudinal and transverse cracking, bleeding, rutting, weathering, etc.

Appendix D provides detailed information and photographs documenting the PCI visual inspections.

E.3.1 Site Conditions

The two agencies used for this analysis present significantly different climatic conditions, as well as different type of slurry seal systems have been employed to fulfill their preventive maintenance requirements. Due to budget and time limitations, only two agencies were included in this analysis.

Climatic conditions between the two locations differ significantly. The following tables present normal precipitation and normal temperature data for the City of Chula Vista (weather station Chula Vista) and Sacramento County (weather station Sacramento 5 ESE).

Table 14 - Chula Vista weather station data

(NCDC COOP ID 041758, elevation 56 ft, Lat/Lon: 32°38'N / 117°05'W)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max °F	68.5	68.8	68.4	70.2	70.3	72.6	76.1	78.3	78.7	76.4	72.2	68.8	72.4
Mean °F	57.3	58.3	59.2	61.5	63.7	66.5	70.1	71.8	71.2	67.1	61.0	57.2	63.7
Min °F	46.1	47.7	50.0	52.8	57.1	60.3	64.0	65.3	63.7	57.7	49.8	45.5	55.0
Precipitation (Inch)	1.99	1.99	2.07	0.69	0.14	0.08	0.03	0.08	0.20	0.39	1.11	1.18	9.95

Table 15 - Sacramento weather station data

(NCDC COOP ID 047633 elevation 22ft, Lat/Lon: 38°35'N / 121°130'W)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max °F	55.1	62.2	67.0	73.9	81.6	88.8	93.8	92.5	88.6	79.2	64.2	55.0	75.2
Mean °F	48.2	53.5	57.1	61.7	67.9	73.6	77.4	76.7	73.8	66.4	55.1	47.7	63.3
Min °F	41.3	44.7	47.1	49.5	54.1	58.4	60.9	60.8	59.0	53.6	45.9	40.4	51.3
Precipitation (Inch)	4.18	3.77	3.15	1.17	0.60	0.18	0.05	0.05	0.37	1.00	2.59	2.76	19.87

The City of Chula Vista has developed a modified version of the Greenbook Section 600-3 specifications which allows the use of a Type II slurry seal gradation. The pavement management database did not provide detailed information on slurry seal specification requirements for any of the sections evaluated. All projects evaluated under this Section, as stated by City personnel, correspond to a Type II slurry seal treatment.

Sacramento County employed conventional slurry seals (CQS) for their preventive maintenance projects. Currently, all slurry seal projects specified an emulsified asphalt grade CQS-1H with liquid rubber latex additive. The projects evaluated under this Section, as stated by City personnel, correspond to conventional (CQS) slurry seal treatments. The pavement management database did not provide detailed information on slurry seal specification requirements for any of the sections evaluated.

Currently the County uses a Type II gradation on residential streets, as well as on some collectors. The County has developed their own specifications for slurry seal, which in most cases are more stringent than Caltrans Section 37-2 specifications. Mix design requirements follow ISSA test procedures and specifications requirements, except for Wet-track abrasion loss, one hour soak which was changed from the ISSA recommended value of 75 g/ft^2 to 50 g/ft^2.

Appendix F contains current slurry seal specifications used by both agencies.

E.3.2 City of Chula Vista Evaluation Sections (Fast Track)

Table 16 presents pavement management information for the Historical Sections (treated with the REAS slurry seal system) that were analyzed. Information was obtained from the City of Chula Vista Pavement Management System and from visual inspections performed by MACTEC personnel in October 2007.

Table 16 - Chula Vista historical pavement management data

Street Name	Beginning	Ending	Length (ft)	Width (ft)	Area (ft^2)	Construction Date	Type of Slurry	Application Date	2006 PCI *
Cedarbend Way	Redbud Rd	Beechglen Dr	933	34	31722	8/1/1983	REAS	8/1/2000	89
Bristol Ct	Hampton Ct	West end	852	33	28116	8/1/1985	REAS	8/1/2000	72
Coltridge Ln	Corral Canyon Rd	Trailridge Dr	822	33	27126	8/1/1987	REAS	8/1/2000	90
Dartmouth St	Baylor Ave	Mills St	1002	34	34068	8/1/1969	REAS	8/1/2000	77
East Whitney St	Hilltop Dr	Carla Ave	361	33	11913	8/1/1950	REAS	8/1/2002	94
Tranquilo Ln	Hilltop Dr	West end	896	31	27776	8/1/1976	REAS	8/1/2002	89
Mission Ct	East J St	West end	832	34	28288	8/1/1964	REAS	8/1/2002	95
Calle Candelaro	Calle Santiago	Corte de Cera	574	33	18942	8/1/1974	REAS	8/1/2002	100
Diamond Ct	East Naples St	Diamond Dr	284	33	9372	8/1/1989	REAS	8/1/2002	73
Calle La Mirada	Camino Elevado	Calle Escarpada	995	34	33830	8/1/1964	REAS	3/1/2004	86
Wrangler Ct	Surrey Dr	East End	494	34	16796	8/1/1974	REAS	3/1/2004	88
Huerto Pl	Rancho del Rey Pkwy	Pedera Wy	861	33	28413	8/1/1995	REAS	3/1/2004	95

* 2006 PCI values correspond to City's Pavement Management database values.

Street Name	Beginning	Ending	Roadway Type	Type of Slurry	Gradation	Slurry Service Life (years)	2007 PCI *	Weathering Distresses	
								Severity	Area (%)
Cedarbend Way	Redbud Rd	Beechglen Dr	Residential	REAS	Type II	7	89	Low	20
Bristol Ct	Hampton Ct	West end	Residential	REAS	Type II	7	72	Low	40
Coltridge Ln	Corral Canyon Rd	Trailridge Dr	Residential	REAS	Type II	7	90	Low	20
Dartmouth St	Baylor Ave	Mills St	Residential	REAS	Type II	7	77	Low	20
East Whitney St	Hilltop Dr	Carla Ave	Residential	REAS	Type II	5	94	Low	35
Tranquilo Ln	Hilltop Dr	West end	Residential	REAS	Type II	5	89	Low	10
Mission Ct	East J St	West end	Residential	REAS	Type II	5	95	Low	20
Calle Candelaro	Calle Santiago	Corte de Cera	Residential	REAS	Type II	5	100	Low	5
Diamond Ct	East Naples St	Diamond Dr	Residential	REAS	Type II	5	73	Low	20
Calle La Mirada	Camino Elevado	Calle Escarpada	Residential	REAS	Type II	3	86	Low	2
Wrangler Ct	Surrey Dr	East End	Residential	REAS	Type II	3	88	Low	5
Huerto Pl	Rancho del Rey Pkwy	Pedera Wy	Residential	REAS	Type II	3	95	Low	2

** 2007 PCI values were calculated from the visual inspections performed by MACTEC personnel.*

E.3.3 Sacramento County Evaluation Sections (Fast Track)

Table 17 presents pavement management information for the analyzed Historical Sections treated with the REAS slurry seal system. Information was obtained from the County of Sacramento Pavement Management System and from visual inspections performed by MACTEC personnel in May 2008.

Table 17 - Sacramento historical pavement management data

Street Name	Beginning	Ending	Length (ft)	Width (ft)	Area (ft²)	Construction Date	Type of Slurry	Application Date	2006 PCI *
Blue Oak Dr	Madison Ave	Main Ave	3580	42	150360	1975	CQS Slurry	May 2002	91
Cordova Ln	Folsom Blvd	Zinfandel Dr	2550	42	107100	1966	CQS Slurry	May 2002	92
Eugenia Ct	Pershing Ave	Cul de Sac	325	26	8450	1990	CQS Slurry	May 2002	92
Great Dome Ct	Minding Oad Ct	Cul de Sac	110	26	2860	1981	CQS Slurry	May 2002	92
Hirschfeld Wy	Zinfandel Dr	Berrywood Dr	2320	36	83520	1972	CQS Slurry	May 2002	92
Long Canyon Dr	Winding Oak Dr	Winding Oak Dr	2890	42	121380	1977	CQS Slurry	May 2002	92
Mist Ct	Pershing Ave	Cul de Sac	425	26	11050	1966	CQS Slurry	May 2002	92
Orange Ave	Pennsylvania Ave	New York Ave	1300	18	23400	1966	CQS Slurry	June 2002	92
Quad Ct	Olive St	Cul de Sac	315	27	8505	1966	CQS Slurry	June 2002	92
Stageline Ct	Lond Canyon Dr	Cul de Sac	370	26	9620	1977	CQS Slurry	May 2002	73
Vista Dome Ct	Winding Oak Ct	Cul de Sac	105	26	2730	1981	CQS Slurry	May 2002	92
El Terraza Dr	Gerber Rd	Napier Wy	775	36	27900	1966	CQS Slurry	May 2006	85
Fairlawn Ct	El Terraza Dr	West End	260	26	6760	1966	CQS Slurry	May 2006	85
Glacken Wy	Gerber Rd	Napier Wy	790	26	20540	1966	CQS Slurry	May 2006	85
Napier Wy	West End	East End	1295	26	33670	1966	CQS Slurry	May 2006	85
Theodore Ave	Glacken Wy	El Terraza Dr	540	26	14040	1966	CQS Slurry	May 2006	85

** 2006 PCI values correspond to City's Pavement Management database values.*

Street Name	Beginning	Ending	Roadway Type	Type of Slurry	Gradation	Slurry Service Life (years)	2007 PCI *	Weathering Distresses	
								Severity	Area (%)
Blue Oak Dr	Madison Ave	Main Ave	Residential	CQS	Type II	5	65	Low	10
Cordova Ln	Folsom Blvd	Zinfandel Dr	Residential	CQS	Type II	5	47	Low	15
Eugenia Ct	Pershing Ave	Cul de Sac	Residential	CQS	Type II	5	94	Low	10
Great Dome Ct	Minding Oad Ct	Cul de Sac	Residential	CQS	Type II	5	34	Low	15
Hirschfeld Wy	Zinfandel Dr	Berrywood Dr	Residential	CQS	Type II	5	62	Low	15
Long Canyon Dr	Winding Oak Dr	Winding Oak Dr	Residential	CQS	Type II	5	89	Low	15
Mist Ct	Pershing Ave	Cul de Sac	Residential	CQS	Type II	5	96	Low	5
Orange Ave	Pennsylvania Ave	New York Ave	Residential	CQS	Type II	5	73	Low	20
Quad Ct	Olive St	Cul de Sac	Residential	CQS	Type II	5	85	Low	30
Stageline Ct	Lond Canyon Dr	Cul de Sac	Residential	CQS	Type II	5	47	Low	15
Vista Dome Ct	Winding Oak Ct	Cul de Sac	Residential	CQS	Type II	5	31	Low	25
El Terraza Dr	Gerber Rd	Napier Wy	Residential	CQS	Type II	1	71	Low	0
Fairlawn Ct	El Terraza Dr	West End	Residential	CQS	Type II	1	70	Low	0
Glacken Wy	Gerber Rd	Napier Wy	Residential	CQS	Type II	1	62	Low	0
Napier Wy	West End	East End	Residential	CQS	Type II	1	62	Low	2
Theodore Ave	Glacken Wy	El Terraza Dr	Residential	CQS	Type II	1	68	Low	0

** 2007 PCI values were calculated from the visual inspections performed by MACTEC personnel.*

E.3.4 Findings "Fast Track Approach"

The evaluation of existing slurry seals projects under Phase III "Fast Track Approach", due to its nature, was an observational study with limited controls, factors such as very limited and insufficient pavement management and historical inspection data, plus other unknown confounding factors added some scatter and noise to the results.

The primary limitation for this evaluation was the limited and insufficient pavement management and inspection data for the projects evaluated. The pavement management information provided by both agencies was insufficient to accurately quantify and document the condition of the in-place asphalt concrete (AC) pavement prior to the slurry seal application. The condition of the underlying pavement is one of the most critical factors related to the performance of the slurry seal or any other pavement preservation treatment applied, and this lack of PCI data for that pavement is a confounding factor in evaluating performance.

Slurry seals when applied do not provide any additional structural strength to a pavement section, but as described by the Asphalt Institute "can help reduce surface distress caused by oxidation of the asphalt and the embrittling of the paving mixture. It will seal the surface

cracks, stop raveling and loss of matrix, and make open surfaces impermeable to air and water, and improve skid resistance and pavement appearance."

Condition surveys identified locations of structural failure on the pavement, but insufficient pavement management data unable us to evaluate accurately the rate of progression of these distresses over time after the application of the slurry seal. In order to omit all distresses not related to the slurry seal from the analysis, the focus was made on the performance evaluation of the slurry seal projects to only weathering deterioration on the slurry. It is important to highlight that two different slurry seal systems were used by the two agencies under analysis, as well as the very different climatic conditions present in both locations. This approach tried to provide a more leveled field for performance comparison between projects, within the data limitations encountered and disregarding the very different climatic conditions for the two locations.

Figure 10 presents deterioration curves for weathering distresses on the slurry seal sections evaluated in the City of Chula Vista and Sacramento County, based on the evaluation approach described in the paragraph above.

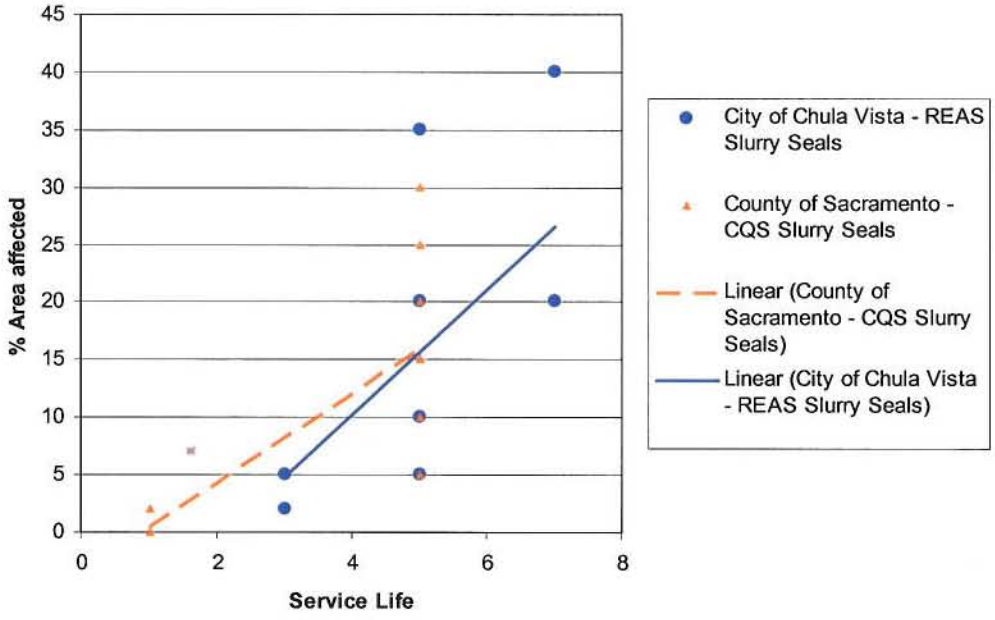


Figure 10 - Weathering deterioration Chula Vista and Sacramento County

E.4 "NEW PROJECTS APPROACH" - FIELD PERFORMANCE CONSIDERATIONS

In order to better account for factors that may affect slurry seal performance that are not available for the in-place materials, the New Projects Approach was developed to use planned upcoming slurry seal projects in Agencies (Cities and Counties) throughout California. These agencies were willing to participate in an inter-agency agreement with the CIWMB.

Such agreements allowed to follow the applicable procedures detailed in the February 2005 report "Generic Experimental Design for Product/Strategy Evaluation – Crumb Rubber Modified Materials" which MACTEC developed for the Caltrans-CIWMB Partnered Research Project.

The sections selected for this field performance study where:

City of Chula Vista

1. East Moss Avenue
2. Finch Place
3. Oak Place
4. Lantana Avenue
5. Nile Avenue

Sacramento County

1. Tallyho Drive
2. Rose Valley Way

Pleasant Hill

1. Harriet Drive

Prior to surface preparation, MACTEC representatives identified performance evaluation sections (PES) for condition survey of existing pavement conditions and/or distress that may affect performance of the finished slurry seal product.

Slurry seal mix designs where submitted by the contractor. MACTEC engineers observed slurry seal placement and identified construction-related factors that might impact performance and obtained samples of the slurry mix and component materials during construction for compliance testing.

Condition surveys of the PES were performed after construction and should continue on an annual basis for as long as the Board is willing to continue funding the evaluation or until the subject slurry seals are replaced, whichever comes first. Data collection over time and analysis with respect to materials properties, site and pavement conditions, and construction, will provide a better understanding of how these slurry seal materials perform and how best to employ them.

Slurry Seal Specifications Used

The City of Chula Vista has developed a modified version of the Greenbook Section 600-3 specifications which allows the use of a Type II slurry seal gradation. Appendix F shows a copy of these specifications.

Sacramento County and City of Pleasant Hill used the City of Chula Vista modified specification of the Greenbook Section 600. Sacramento County used a Type I gradation, while the City of Pleasant Hill used a Type II gradation slurry seal for the construction of the REAS slurry seal evaluation sections analyzed in this Section.

E.4.1 City of Chula Vista Evaluation Sections (New Project Approach)

The Chula Vista evaluation sections on Nile Avenue and East Moss Avenue were placed October 15, 2007 between 10 a.m. and 11 a.m.; meanwhile the evaluation sections on Lantana Avenue, Finch Place, and Oak Place were constructed October 18, 2007 between 10 a.m. and 2 p.m.

Placement conditions on October 15, 2007 where considered marginal for slurry seal placement with almost a complete cloud cover throughout the day and a light breeze. Ambient temperature during placement was 64 °F and pavement temperatures ranged from 72 to 74 °F. On October 18, 2007 placement conditions were more favorable with an ambient temperature ranging from 68°F to 80°F and pavement temperatures ranged from 76°F and 96°F.

The following table shows the pre-treatment PCI and weathering condition of the evaluation sections. Appendix E provides photographs of the evaluation section pre-existing conditions, as

well as treatment application and final product appearance. Tables 18 and 19 show REAS test results from the City's Quality Assurance Program

Table 18 - Chula Vista quality assurance aggregate test results

Location		Broadway & Moss	Broadway & Moss
Aggregate Gradation	Requirements	10/15/07	10/18/07
# 4	90-100	100	100
# 8	65-90	87	87
#16	45-70	57	55
# 30	30-50	37	36
# 50	18-36	24	24
# 100	10-24	16	16
# 200	5-15	11	11
Sand Equivalent Test	55 Min.	66	67

Table 19 - Chula Vista quality assurance REAS test results

Location		747 Kearney St	480 Davidson	168 E. Olympia	161 E. Olympia	640 Mariposa Circle Mid Sect	640 Mariposa Circle Odd Side	1412 Lantana Ave	1509 Ocala Ct.
Slurry Test Results	Requirements	10/15/07	10/15/07	10/15/07	10/15/07	10/18/07	10/18/07	10/18/07	10/18/07
Water Content (%)	25 Max.	33	30.4	33.7	29.9	30.1	30.3	29	29
Emulsion Content (%)	34.4-36.4	38.5	38.5	37.9	37.5	46.7	38.9	40	40.6
Wet Track Abrasion Weight Loss	50 Max.	50	51	48	52	27	67	34	28

E.4.2 Sacramento County Evaluation Sections (New Project Approach)

The Sacramento County evaluation sections on Tallyho Drive and Rose Valley Way were placed May 16, 2008 between 11 a.m. and 3 p.m. Weather conditions were ideal for slurry seal placement with clear skies and a very light breeze. Ambient temperatures during placement ranged from 86°F to 98°F and pavement temperatures ranged from 122°F to 142°F.

The following table shows the pre-treatment PCI and weathering condition of the test sections. Appendix E provides photographs of the test section pre-existing conditions, as well as treatment application and final product appearance.

E.4.3 City of Pleasant Hill Test Sections (New Project Approach)

The Pleasant Hill evaluation section on Harriet Drive was placed August 25, 2008 between 9 a.m. and 10 a.m. Placement conditions on where appropriate for slurry seal placement with clear skies with a very light breeze. Ambient temperature during placement ranged from 78°F to 80°F and pavement temperatures ranged from 84°F to 90°F.

The following table shows the pre-treatment PCI and weathering condition of the evaluation sections. Appendix E provides photographs of the evaluation section pre-existing conditions, as well as treatment application and final product appearance.

E.5 LABORATORY EVALUATION OF STUDY SECTIONS

Table 20 - Chula Vista, Sacramento and Pleasant Hill REAS Lab test results

Agency		**Chula Vista**				**Sacramento County**	**Pleasant Hill**
Aggregate Gradation	**Requirements**	Type II (Requirements)				Type I (Requirements)	Type II (Requirements)
# 4	Per material type. Requirements in between parenthesis	100 (90-100)				100 (100)	100 (90-100)
# 8		99 (65-90)				100 (90-100)	84 (65-90)
#10		95				99	74
#16		73 (45-70)				81(65-90)	47 (45-70)
# 30		47 (30-50)				53 (40-60)	29 (30-50)
# 40		38				44	24
# 50		31 (18-36)				35 (25-42)	19 (18-36)
# 100		20 (10-24)				22 (15-30)	13 (10-24)
# 200		13.3 (5-15)				14.4 (10-20)	9 (5-15)
Sand Equivalent Test	55	60				65	78
Emulsion	**Requirements**						
Brookfield Viscosity (cPs)	2 500 - 20 000	5176	6026			5989	NA
Residue by Evaporation (%)	50 Min.	52.4	52.9			52.5	NA
Retained on #20 (%)	2.0 Max.	0.18	0.33			3.49	NA
Unit weight (lbs/gallon)	8.33-8.75	8.45	8.4			8.46	NA
Penetration (dmm)	20-40	24	22			20	NA
Solubility of Trichloroethylene (%)	75 Min.	84.45	83.5			88.89	NA
Street		**Nile Ave**	**Lantana Ave**	**Finch Place**	**Oak Place**	**Tallyhoe Way**	**Harriet Dr**
Remixes	**Requirements**						
Mix Time (seconds)	180 Min.	Pass	Pass	Pass	Pass	Pass	Pass
Set Time (minutes)	30 Min.	Pass	Pass	Pass	Pass	Fail	Fail
Cure Time (minutes)	60 Min.	Fail	Fail	Fail	Fail	Fail	Fail
Consistency (mm)	20-40	22	20	21	23	33	36
Wet Cohesion (kg-cm)							
30 minutes	12 Min.	9	9	10	9	9	10
60 minutes	20 Min.	10	9	10	10	9	11
90 minutes		10	10	12	11	10	9
120 minutes		12	11	13	12	12	11
240 minutes		16	19	18	16	14	15
360 minutes						16	17
Cured Samples	**Requirements**						
Wet Track Abrasion, 1 hr soak (g/ft2)	75 Max	82.9	41.6	49.8	55	10.1	5.8
Wet Track Abrasion, 6 day soak (g/ft2)		109.6	105.7	127.2	202.6	43.3	29.1
Load Wheel Test, sand adhesion (g/ft2)	50 Max.	32.3	28.4	29.2	26.8	43.4	37.1
Wet Stripping, retention (%)	90 Min.	>90%	>90%	>90%	>90%	>90%	>90%
British Pendulum, average		83	89	86	94	85	77

E.6 POST-CONSTRUCTION VISUAL INSPECTION EVALUATION

Treatment condition and performance for all REAS Evaluation sections was evaluated and documented by MACTEC personnel in April, 2009. Visual inspections were performed on all sections to evaluate their performance and to document any type of deterioration or distress present on them during their service life. The service life of the REAS test sections varies by Agency; sections in the City Chula Vista have been in service for 18 months, 11 months in Sacramento County and only 7 months for the sections in the City of Pleasant Hill.

This section describes the results of the post/construction visual inspections performed on the REAS Evaluation Sections. In addition to the photograph presented in this section, a wider selection of photographs is also being included in Appendix E "Phase III New Projects Approach – Pavement Condition Evaluation Photographs".

E.6.1 City of Chula Vista

The REAS slurry seal type II sections evaluated in the City of Chula Vista have been in service for 18 months, at the time of this visual inspection. All five sections evaluated for this study are being described below.

East Moss Avenue: Some areas in the REAS slurry seal evaluation section are showing signs of accelerated weathering deterioration, with even some of the coarser aggregate particles being dislodged off the treatment (See Figure 11). Some color fading is visible, but overall slurry seal coloration is acceptable.

Cracks have reflected through the slurry seal, even though most cracks were filled before the surface treatment application. No documentation was requested or provided by the City in regard to the type of crack sealant used, but will be important for the City to evaluate performance of this material. MACTEC considers crack sealing and crack filling a very important preparation procedure before any type of surface treatment application is done. Sealant material shall be selected based on temperature, traffic and pedestrian traffic requirements from an approved source. Material shall be sampled and tested prior to installation.

The following Figure 12 shows before treatment application and current condition of a section were cracks propagated through the slurry seal. It is important to mention that the edges of the patch were not sealed and cracks reflected through the surface treatment. Crack propagation is also visible in other areas where the cracks were filled.

Figure 11 - Weathering deterioration E Moss Ave, Chula Vista

Figure 12 - Reflective cracking prior to treatment E moss Ave, Chula Vista

Finch Place: Surface treatment appearance is rough and some weathering deterioration is evident in evaluation sections, as shown in Figure 13. Crack sealant is not performing adequately with a significant amount of cracks already reflecting through the slurry seal, as shown in Figure 14.

Figure 13 - Slurry seal appearance Finch Ave, Chula Vista

Figure 14 - Reflective cracking Finch Ave, Chula Vista

Lantana Avenue: Some weathering deterioration is appreciable, but in a lesser extent compared to the other sections evaluated in the City of Chula Vista. Some fine aggregates are dislodging off the treatment; no evident of coarser particles stripping off the treatment was appreciated. Few cracks have reflected through the REAS. Figure 15 presents some examples of the condition of this evaluation sections.

At the end of this evaluation section, a newer slurry seal treatment was applied possibly in 2009, figure 16 presents the surface appearance of both sections.

Figure 15 - Slurry seal Lantana Ave, Chula Vista

Figure 16 - REAS Lantana Ave, Chula Vista

Nile Street: Extensive crack filling was done on this section before the application of the REAS, even though as observed and documented during this inspection most crack have reflected through the REAS. See Figure 17. Weathering distresses were identified on the slurry seal, limited to some loss of fine aggregate. A more severe weathering condition was observed next to the cracks as shown in Figure 18.

Figure 17 - REAS Nile Street, Chula Vista

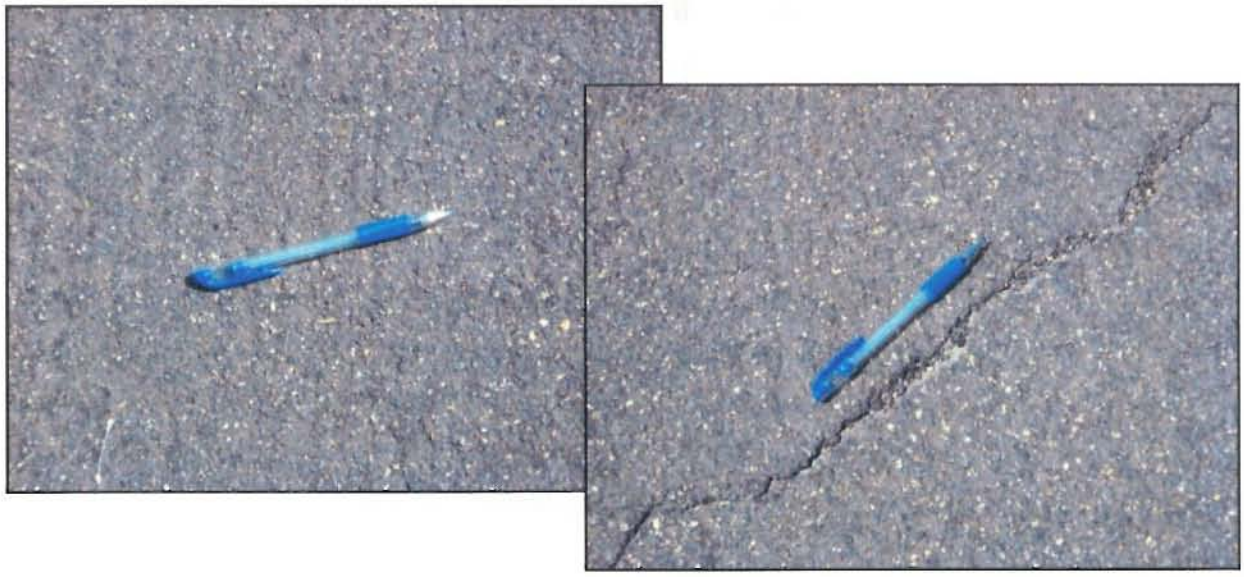


Figure 18 - REAS weathering Nile Street, Chula Vista

Oak Place: Similar deterioration as on the other sections in Chula Vista is present in this section, with some weathering and fine aggregate loss of the treatment surface, as well as cracks reflecting through the REAS treatment. Some areas present a rough texture, see Figure 19. Figure 20 shows the delaminations of the REAS which was found on two locations. The probable cause of this deterioration is the improper preparation and cleaning of the pavement before the application of the slurry seal.

Figure 19 - Slurry seal Lantana Ave, Chula Vista

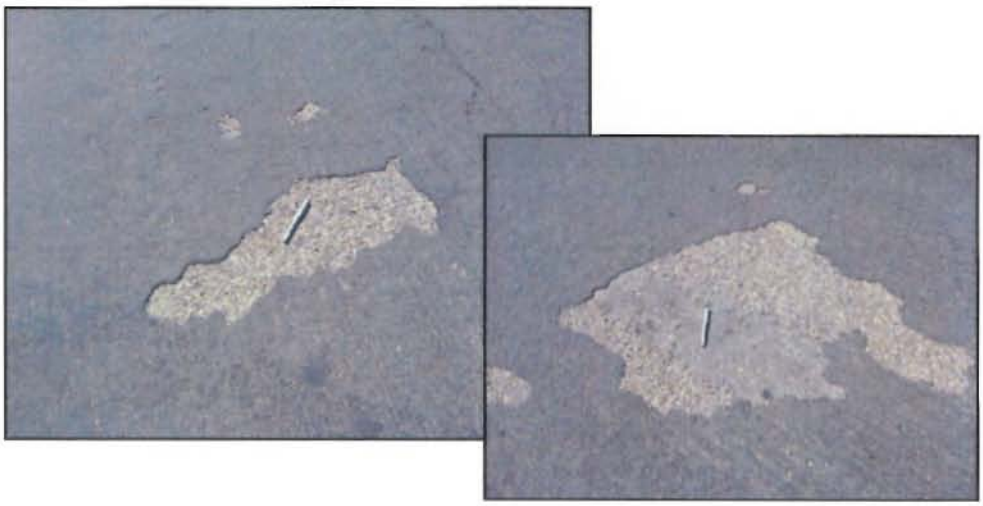


Figure 20 – REAS delamination Lantana Ave, Chula Vista

E 6.2 Sacramento County

The REAS slurry seal type I sections evaluated in the County of Sacramento have been in service for 11 months, at the time of this visual inspection. The two sections evaluated for this study are being described below.

Rose Valley Way: REAS treatment appearance and texture are optimal, no weathering deterioration was observed on this evaluation section. Figure 21 shows the overall condition of the REAS on Rose Valley Way. Some fatigue or alligator cracking has reflected through the slurry seal in one location north of the intersection of Rose Valley Way and Oxwood Drive. This section was not repaired before the application of the surface treatment. (See Figure 22)

Figure 21 - Slurry seal Rose Valley Way, Sacramento County

Figure 22 - Fatigue cracking Rose Valley Way, Sacramento County

Tallyho Drive: REAS treatment in good condition. Some areas identified exhibited conditions conducive with poor workmanship, including very thin seal applications, areas that were not sufficiently cleaned properly and fat spots. See figures 23 and 24. No crack sealing or crack filling was done before the slurry application; some cracks have reflected through the treatment.

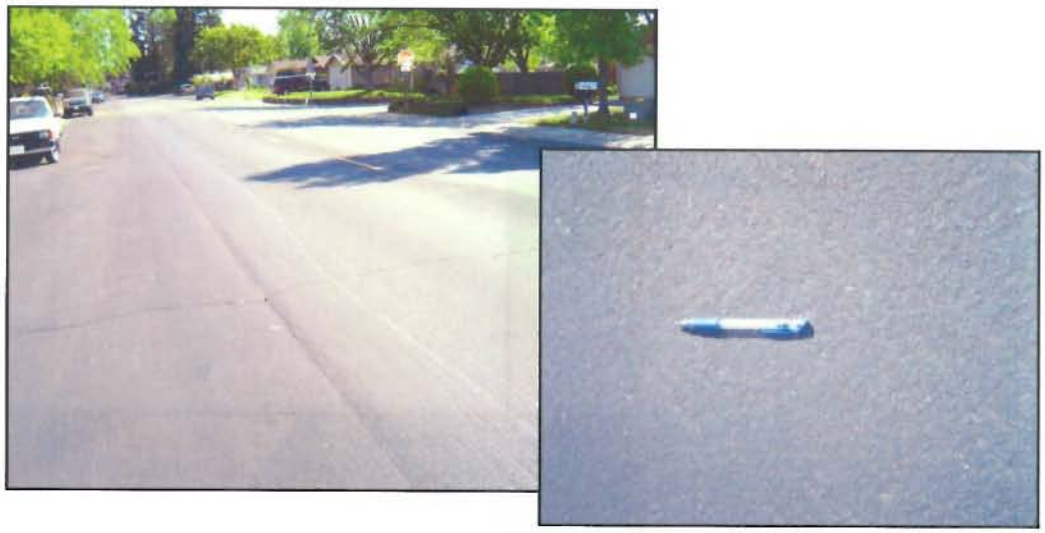


Figure 23 - Slurry seal Tallyho Drive, Sacramento County

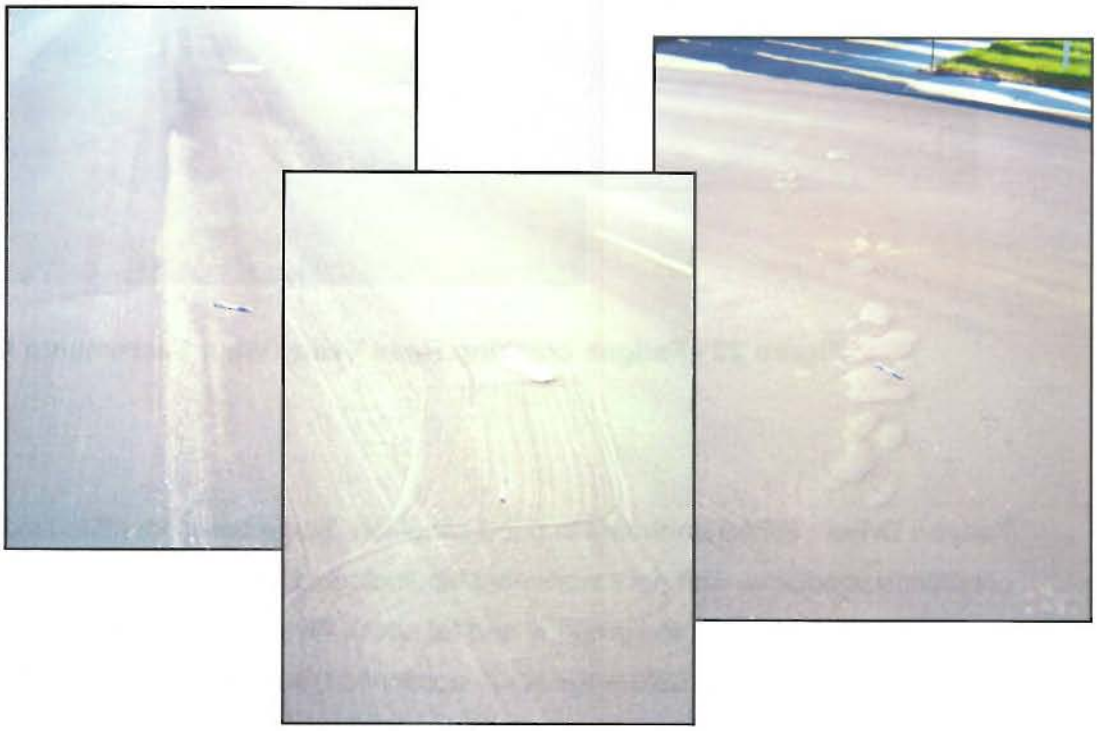


Figure 24 - Poor workmanship Tallyho Drive, Sacramento County

E 6.3 City of Pleasant Hill

Harriet Drive: The REAS slurry seal type II section evaluated in the City of Pleasant Hill has been in service for only 7 months, at the time of this visual inspection. Some weathering deterioration was identified on this section; aggregate particles have been dislodging off the treatment. Coated aggregates were observed on the sides of the road. Some cracks have reflected through the treatment, some spots with power-steering damage possibly during the setting and curing stages of the application were identified, and a location with some fatigue cracking was found. Figures 25 and 26 show the surface appearance and distresses identified on Harriet Drive.

Adjacent to the REAS evaluation sections a microsurfacing was placed three weeks before the REAS. Due to the differences in pavement configurations, no pavement performance comparison will be done between the two treatments. But the two treatments were able to be compared based on weathering deterioration, appearance and texture. Color, appearance, and texture were very similar between the two, but weathering deterioration was higher on the REAS evaluation section. See Figure 27.

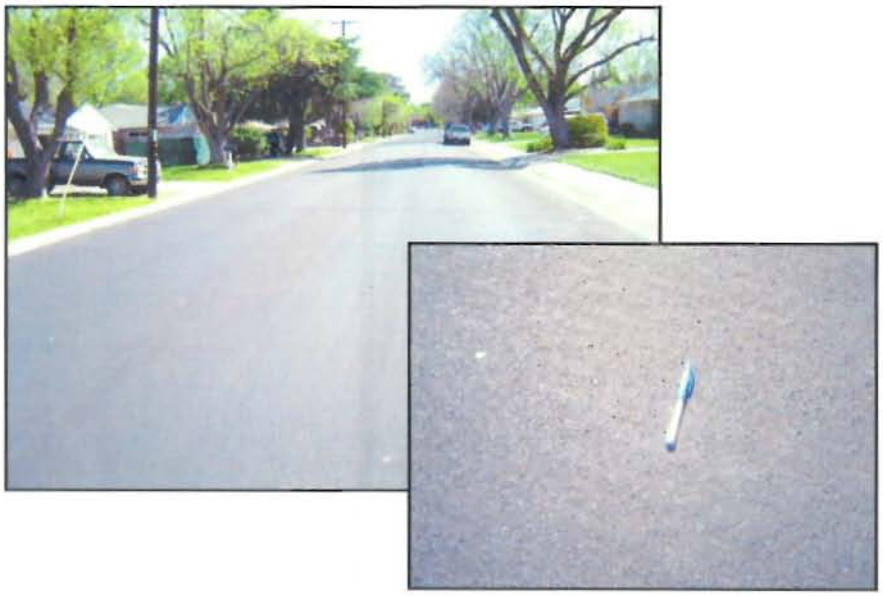


Figure 25 - Slurry seal Harriet Drive, Pleasant Hill

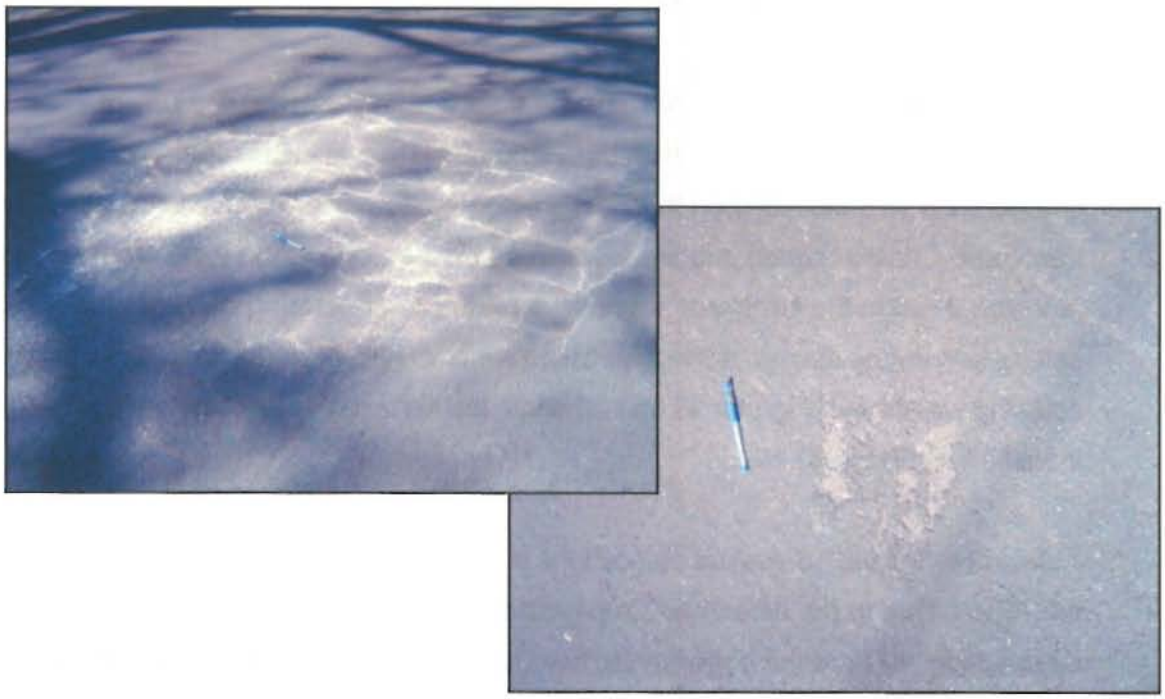


Figure 26 - Fatigue cracking and vehicle scouring Harriet Drive, Pleasant Hill

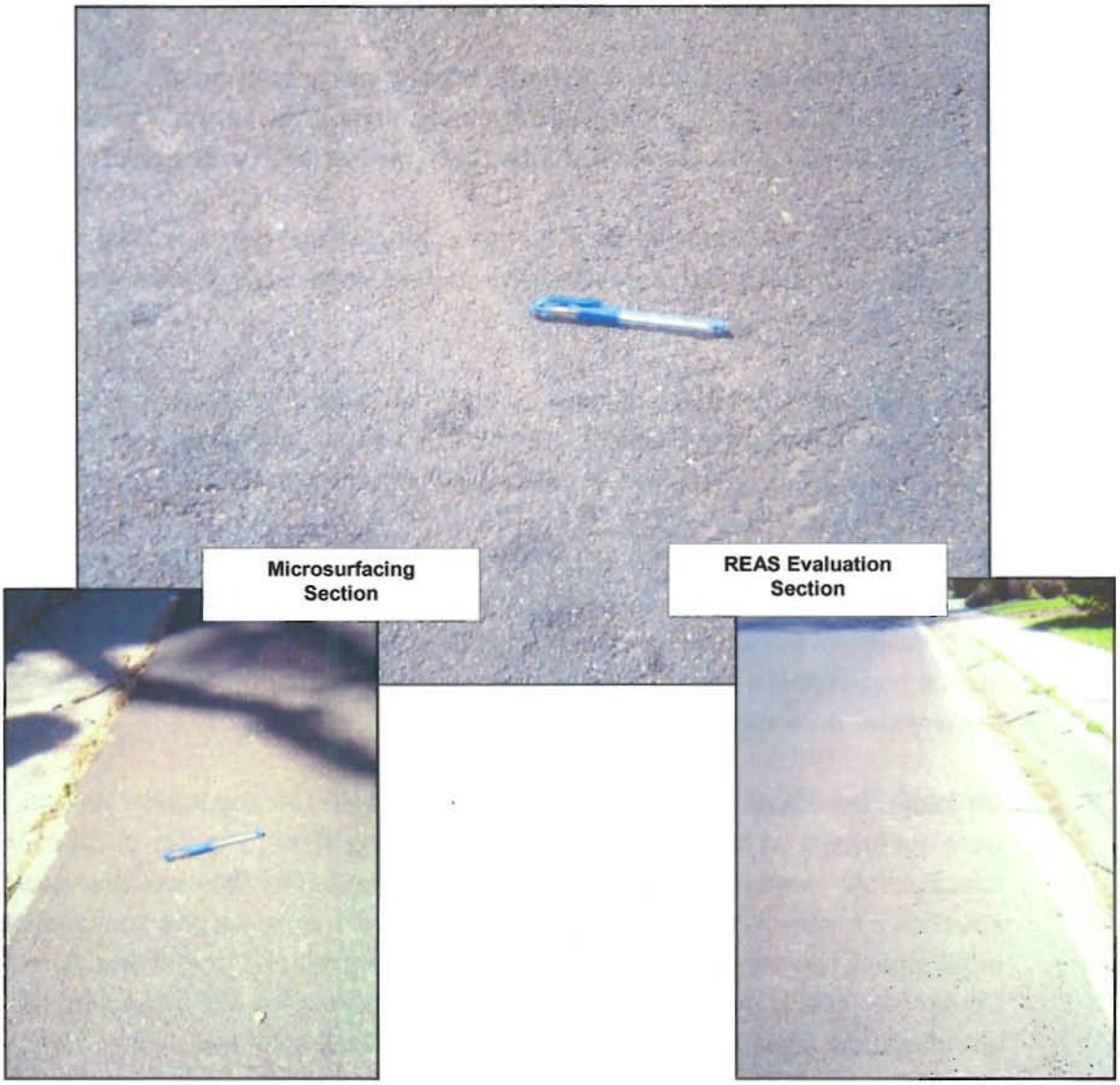


Figure 27 - REAS and Microsurfacing comparative Harriet Drive, Pleasant Hill

E.7 POST-CONSTRUCTION EVALUATION SECTION FINDINGS

In general terms, the placement of the REAS slurry seal systems was no different to the placement of other types of slurry seal systems, according to visual observations made during placement and comments solicited from contractor's construction crews.

Environmental conditions appear to be more stringent for REAS systems due to the anionic characteristic of the material needing an apparent longer setting and curing period required before opening the sections to traffic.

All REAS samples failed the 60 minutes minimum curing time requirement. Two samples, Sacramento County and Pleasant Hill, failed as well the 30 minutes minimum set time requirement. All samples failed the wet cohesion requirements at 30 and 60 minutes.

This behavior was observed during the placement of sections in Nile Avenue and East Moss Avenue, October 15, 2007. Climatic conditions during construction were not ideal for slurry seal placement but within specifications; with ambient temperatures of 64 °F and a light breeze and almost a complete cloud cover throughout the day. Eight hours after placement some areas were still wet and coned off to traffic. See Figure 11.

Minimum Greenbook requirements (75 g/ft^2) for the Wet track abrasion test one hour soak were not fulfilled on one sample (Nile Avenue, Chula Vista). The City of Chula Vista REAS specifications, which were used for by all three Agencies for the evaluation sections, specifies a minimum value of 50 g/ft^2 for the Wet track abrasion one hour soak; with this requirement, two samples would have failed and one result is border line. Also, the City of Chula Vista quality assurance program test results show 3 out of 8 samples failing the 50 g/ft^2 maximum loss for the Wet track abrasion one hour soak test.

The Wet track abrasion 6 day soak results show the same behavior observed in Phase II – Laboratory Evaluation of Slurry Seals, with most samples exhibiting a high loss after a soaking period of 6 days. Four samples of six tested show a loss value over 100 g/ft^2.

Figure 11 - REAS slurry seal evaluation Nile Ave 8 hours after placement Chula Vista

Section F CONCLUSIONS AND RECOMMENDATIONS

F.1 PRELIMINARY RECOMMENDATIONS AND CONCLUSIONS

User respondents indicated that REAS Slurry Seals are the most widely used slurry seal product in the Los Angeles area. REAS is more expensive than conventional or polymer-modified slurry materials. Differences in service life may be a reflection of the differences in condition of the pavements that are slurry sealed. REAS applications tend to be used in situations where the pavement condition may be marginally poor for a slurry application.

Based upon the Phase I surveys, industry respondents appear to have a different perception of REAS Slurry Seals service life. Table 9 indicates REAS Slurry Seals have the shortest expected service life of the products listed. Specialty products listed as others are more expensive than REAS.

REAS require more stringent placement requirements, based mostly in part to the required longer setting and curing periods. REAS samples also had difficulties fulfilling cohesion requirements at 30 and 60 minutes.

When all three Slurry Seal Systems were compared in the lab, the system with the highest Wet Track abrasion one hour soak loss was the conventional (CQS) samples, but test results were still well below specification requirements. The polymer modified emulsion shows the best performance of the three systems when evaluated for Wet-track abrasion for both one hour and six-day soak.

The REAS samples show a significantly higher loss for the Wet-Track abrasion six-day soak in comparison with the CQS and the Polymer Modified Slurry Seals. These higher losses could be an indicator of a material with higher susceptibility to moisture damage.

The British Pendulum results for all three systems are very similar; even though the REAS samples were prepared with a Type I gradation, as most of the agencies contacted reported using this type of gradation, meanwhile a Type II gradation was used for the Polymer Modified and the CQS slurry seals.

Due to limited pavement management data, Phase III – "Fast Track Approach" was inconclusive and more data is required for valid conclusions. Field performance trends for the REAS and the Conventional Slurry Seal Systems evaluated were presented in section E.4 Findings

Greenbook specifications for Rubberized Emulsion - Aggregate Slurry (REAS) appear to allow a relatively wide range of binder products.

Greenbook specifications did not include/allow for Polymer Modified Slurry seals, unless they were a component within the REAS design.

Survey results indicated that users perceive considerable benefits from using REAS materials, but the role of the rubber in providing some of these benefits is not clear. It appears that the tire rubber is generally mixed with already prepared latex-modified emulsion. Since the binder is an asphalt emulsion, binder temperatures are typically in the range of 140-160°F. This is well below the range needed for any significant interaction to occur between the tire rubber and the asphalt cement.

It appears that in REAS systems, the Crumb Rubber Modifier (CRM) acts primarily as filler in the binder and/or as elastic aggregate, rather than as an asphalt modifier. The carbon black in the tire rubber appears assist in keeping the REAS surface black. It is possible that some of the antioxidants and other anti-aging components in the CRM may help reduce aging of the binder. The inclusion of CRM does not appear to have adverse effects.

Reported reduced aging may also be a function of reportedly higher binder contents of the REAS mixes compared to conventional slurry seals, but binder content data was not provided for review.

Based on upon information supplied by Flexseal brochure data (a REAS product), the amount of rubber used within their REAS products was calculated as follows:

$$\text{One lane mile} = 5{,}280 \text{ ft} \times 12\text{ft} = 63{,}360 \text{ ft}^2$$

$$\frac{774 \text{ pounds of rubber}}{63{,}360 \text{ ft}^2} = 0.012 \text{ pound of rubber/ ft}^2$$

$$\frac{0.012 \text{ lb of rubber/ ft}^2}{12 \text{ lbs of rubber/tire}} = 0.001 \text{ tires/ ft}^2$$

$$\frac{774 \text{ pounds of rubber}}{12 \text{ lbs of rubber/tire}} = 64.5 \text{ tires per lane mile of RSS}$$

Based on Greenbook Section 600-3, Rubberized Emulsion-Aggregate Slurry (REAS) rubber content of emulsion ranges from about 6.6 to 7.4% by weight of Rubberized Polymer Modified Emulsion (RPME). Since minimum residue requirement is 50%, these values would at least double to provide minimum range of about 13.2 to 14.8% CRM by weight of residual and may yield CRM contents comparable to that of high viscosity asphalt rubber binders (minimum 18% CRM by total binder weight). However, the specified application rate of the slurry seal ranges from 28 to 40 square feet per gallon, so the amount of rubber per unit area is comparable to that indicated above.

The interim findings of the Caltrans study report on studies in the pavement preservation area in the determination of benefits of pavement preservation using city and county data in California included the following preliminary recommendations and conclusions.

The data received from various local agencies contain mostly recent records, less than 10 years. Most of the old records are either incomplete or insufficient. Erroneous records were also found during the analysis. For example, unreasonable and unexplainable changes in the pavement condition index (PCI) ratings over time with no maintenance treatment being applied.

It was anticipated that the traffic applications and climate would have considerable effects on the performance of the pavement and treatments; these effects were not able to be quantified because of the lack of appropriate information.

The treatment life of the studied pavement preservation treatment was significantly affected by the pre-existing condition of the pavements. A treatment applied on a surface in good

condition would last much longer than the same treatment applied on a road in poor condition. For the three treatments studied, the following were found based on the PCI data.

These lives were determined when PCI dropped to 70 after the treatment.

1. Slurry seal – life ranges from 2 to 9 year
2. Asphalt concrete overlay – life ranges from 7 to 16 years
3. Rubberized asphalt concrete overlay - life ranges from 7 to 15 years

When using the cracking data for a cracking level of 5%, the following were noticed:

1. Slurry seal – life ranges from 3 to 7 year
2. Asphalt concrete overlay – life ranges from 7 to 15 years
3. Rubberized asphalt concrete overlay – unable to determine with very limited data

The combined analysis indicated that when the slurry seal or asphalt concrete overlay reached 5% cracking, the treatment life could deteriorate rather quickly depending on the existing pavement condition.

The life cycle cost analysis indicates that for the three scenarios studied the option with proactive pavement preservation treatments could save as much as 24% annually in terms of the total savings as compared to that without pavement preservation for the same analysis period.

The local agencies should continue their effort in collecting desired and needed data (including traffic and cost information) and storing these data in the pavement management system for determining how each treatment has performed for their jurisdiction and using the data to refine strategies for future treatment applications.

This study indicates a combined analysis of cracking and PCI data may provide a better assessment of pavement condition and treatment life. This study also suggests that a 5% cracking level might be appropriate to use as a trigger value for considering a pavement preservation treatment as pavement would deteriorate rather rapidly afterwards.

All evaluation sections should be visited and visually inspected on an annual basis, to monitor performance, to evaluate and document crack propagation, including moisture damage. It should be noted that seasonal variability may also be a factor for determination of the annual monitoring frequency required for future and or continued test section evaluation.

With regard to pavement preservation treatments, the group that slurry seal are included within, have no readily available predictive tests on how long treatments will last. This is due in part to the pre-existing condition of the pavements, climatic conditions, and workmanship and construction practices adopted.

In conclusion the general amounts of tire usage for materials currently used within the paving industry that include rubberized tires can be summarized as follows; and are listed below by type of application, order of magnitude, and tires used per lane mile.

Rubberized Asphalt Concrete (RAC) two lanes overlay, two inches in depth, one mile in length	**2,000 Tires/lane Mile**
Rubberized Asphalt Concrete (RAC) Chip Seal	**545 Tires/lane Mile**
Rubberized Asphalt Terminal Blend two lanes overlay, two inches in depth, one mile in length	**230 Tires/Lane Mile**
Rubberized Emulsion Slurry Seal (REAS)	**65 Tires/Lane mile**

Section H

REFERENCES

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3. Caltrans Asphalt Rubber Usage Guide, 2005

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5. Greenbook, Standard Specifications for Public Works Construction. 2009 Edition. Public Works Standards, Inc.

6. International Slurry Surfacing Association, Web Page: **http://www.slurry.org.history**

7. ISSA Technical Bulletin A105 (Revised) May 2003, Recommended Performance Guidelines for Emulsified Asphalt Slurry Seal, International Slurry Surfacing Association, Annapolis, MD, Web Page: www.slurry.org.

8. ISSA Technical Bulletin A143 (Revised) May 2003, Recommended Performance Guidelines for Micro-Surfacing, International Slurry Surfacing Association, Annapolis, MD, Web Page: www.slurry.org.

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10. National Technical Information System (NTIS), Web Page: **http://www.ntis.gov**

11. Rubber Pavements Association (RPA), Web Page: **http://www.rubberpavements.org**

12. Transportation Research Information System (TRIS), Transportation Research Board (TRB), Web Page: **http://www.trb.org**

13. (FHWA Pooled Fund Study) Caltrans Materials/Infrastructure Section Phase II And III Report Slurry Seal / Micro-Surface Mix Design Procedure (Contract 65A0151) – 2009

14. Caltrans Report on determination of benefits of pavement preservation using city and county data in California (preliminary recommendations and conclusions)

APPENDIX A

LITERATURE REVIEW

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NTL Integrated Search
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Date: Tuesday, August 29, 2006

Record **2** of **4** in **TRIS Online** for **kw:"rubberized slurry"**

Title:	**ALTERNATIVE REFLECTION CRACK TREATMENTS PULVERIZATION AND RUBBERIZED SLURRY SRI**
Accession No:	**00129351**
Authors:	• Snow, R H • Gray, J T • Stickney, E H • Nicholson, R F
Corp. Authors / Publisher:	• Vermont Department Highways
Publication Date:	19750300
Description:	22 p.; Appendices(2); Figures(3)
Abstract:	Nearly five miles of Interstate pavement near the northern Vermont border was rehabilitated during the summer of 1974, using two entirely different methods. A section of approximately two miles was pulverized and compacted and the remainder treated with a strain relieving interlayer of rubberized slurry prior to placement of a two-inch overlay over the entire project. These treatments were required to prevent the reflection of cracks through the new pavement. The two systems were chosen partly as an experimental program and partly due to the varying degree of distress of the pavement. Both were quite similar in cost, with the shortrange benefits nearly equal. However, the pulverization process took a great deal longer than the rubberized slurry application. The performance of the two treatments will be evaluated during the next two winter seasons.
TRT Terms:	Comminution; Compaction; Defects; Driver rehabilitation; Evaluation; Overlays (Pavements); Pavement cracking; Pavement distress; Pavements; Prevention; Reflection cracking; Rubber; Slurry; Surface treating; Time
Other Terms:	Overlay course; Pulverization; Rehabilitation; Slurries; Surface treatment
Subject Areas:	H40 MAINTENANCE, GENERAL
Report Number:	Initial Rept. 75-1 Res. Rept.
TRIS Files:	HRIS
Database:	TRIS Online

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NTL Integrated Search
National Transportation Library

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Of the National Academies

Date: Wednesday, August 30, 2006

Record **11** of **36** in **TRIS Online** for **kw:slurry kw:rubber**

Title: HIGH-TECH SURFACE TREATMENTS AIM AT U.S.
Accession No: 00624694
Authors:
- Kuennen, T

Journal Title:
- Roads & Bridges Vol. 30 No. 12
  http://www.roadsbridges.com/rb/
  Publisher: Scranton Gillette Communications, Incorporated
  ISSN: 8750-9229 OCLC: 11660022

Corp. Authors / Publisher:
- Scranton Gillette Communications, Incorporated
  380 E Northwest Highway, Suite 200
  Des Planes, IL 60016-2282 USA

Publication Date: 19921200
Description: p. 32-33
Languages: English
Abstract: The article briefly reviews a new generation of proprietary, modified microsurfacing and slurry seals that are about to enter the U.S. market from France. Proprietary roadbuilding technologies that were identified during a tour of the French roadbuilding industry are described. Granuchape is a variety of hot, ultra-thin surface treatment which requires specific equipment with which to place it. Flexochape is a rubber-modified asphalt binder which permits storage up to a week at 160 deg. C. The ARC 700 road reclaimer reprocesses old, lower-volume pavements to a depth of 30 cm, using 'hydraulic' binder for material stabilization. Stabicol is a composite paving binder which combines bitumen and portland cement. Styrelf is a ready-to-use product, i.e., a complete proprietary binder. Gripfibre is a cold-applied, proprietary, thin wearing course incorporating synthetic fibers. Other products noted are as follows: Etanplast (durable deck surface treatment for bridges, parking garages, etc.); Novachip, an ultra-thin surfce course for preventive maintenance and surface rehabilitation; and spreaders, emulsion sprayers; and computer controlled bitumen application.
TRT Terms: Binders; Construction equipment; Pavements; Preventive maintenance; Recycling; Rubber; Slurry seals; Surface treating; Wearing course (Pavements)
Geographical Terms:
France
Other Terms: Modifiers; Pavement recycling; Surface treatments; Wearing courses
Subject Areas: H31 BITUMINOUS MATERIALS AND MIXES; I22 Pavement design; H24 PAVEMENT DESIGN AND PERFORMANCE
Availability:
- Scranton Gillette Communications, Incorporated
  380 E Northwest Highway, Suite 200
  Des Planes, IL 60016-2282 USA

TRIS Files: HRIS
Database: TRIS Online

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Date: Tuesday, August 29, 2006

Record **10** of **19** in **TRIS Online** for **kw:rubberized kw:emulsion**

Title: INTERIM REPORT ON NATIONAL EXPERIMENTAL AND EVALUATION PROGRAM (NEEP) PROJECT NO 10-REDUCING CRACKING IN BITUMINOUS OVERLAYS
Accession No: 00098478
Corp. Authors / Publisher:

- Transport and Road Research Laboratory
  Environmental Effects Division
  Crowthorne, Berkshire, RG 11 6AU, England

Publication Date: 19750600
Description: 15 p.
Abstract: The individual States' evaluations of those test features suggested by the Federal Highway Administration are set forth. Experience in the use of Reclamite as asphalt rejuvenating agent is described. This may be sprayed on the existing pavement prior to overlay in accordance with manufacturer's recommendation, or the existing surface may be heated and scarified followed by an application of Recalmite and the overlay. Arizona noted good performance with Reclamite and sections treated with Petroset were noted to be virtually crack free. Other states indicate dissatisfaction with Reclamite in the sealing of reflection cracks, Oklahoma reports a decrease in skid resistance. The use is discussed on Structofors, a woven polyester fabric applied to the existing asphalt pavement surface followed by the overlay. No reflection cracks were reported in some areas while others claimed cracks have appeared in all treated sections. Reports are also made regarding the use of Petromat, a nonwoven polyproylene fabric. Most states noted no cracks with the material, and good bond was evident between the fabric and overlay. Comments are made on plant mix seal (open graded asphalt fraction course) placed in about 5/8 inch thick layer on the existing asphalt pavement followed by the overlay. The seal has been considered effective in reducing reflective cracking. Evaluatory comments are also presented on the following: asphalt emulsion slurry placed on the existing asphalt pavement surface prior to the overlay; the application of Petroset AT Geotechnic Emulsion at the manufacture's recommended rate on the new overlay; and rubberized emulsion slurry seal. In the last (strain relieving interlayer), an asphalt emulsion slurry seal containing (about 23 percent by weight of aggregate) shreds from devulcanized rubber tires is placed on the existing asphalt pavement surface followed by the overlay.
TRT Terms: Asphalt; Bituminous overlays; Emulsified asphalt; Evaluation; Fabrics; Fracture mechanics; Plant mix; Polyester resins; Polypropylene; Reclaimed rubber; Reflection cracking; Sealing compounds; Slurry seals; Structural materials
Other Terms: Cracking (Fracturing); Polyester; Rejuvenation; Rubber tires; Sealants; Structural fabric
Subject Areas: H31 BITUMINOUS MATERIALS AND MIXES; H24 PAVEMENT DESIGN AND PERFORMANCE
Report Number: Intrm Rpt.
TRIS Files: HRIS
Database: TRIS Online

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NTL Integrated Search
National Transportation Library

Transportation Research Board
Of the National Academies

Date: Tuesday, August 29, 2006

Record **4** of **4** in **TRIS Online** for **kw:"rubberized slurry"**

Title: INTERNATIONAL SLURRY SEAL ASSOC 7TH ANNUAL CONVENTION
Accession No: 00218577
Corp. Authors / Publisher:
- International Slurry Seal Assoc

Publication Date: 19690100
Abstract: CONTENTS: PRACTICAL QUICK-SET SLURRY SEAL COATS, CHARLES G SCHMITZ HOW WE USE ASSOCIATION INQUIRIES TO SELL SLURRY, WILL HOFF A CONTRACTOR'S VIEW OF QUICK-SET SLURRY SEALING, WILL HOFF FROST PROOF RUBBERIZED SLURRY, JOHN C. FOSTER LABORATORY EXPERIENCES WITH ASPHALT SLURRIES AND THEIR CONSTITUENTS, E.F. FIOCK SELLING SLURRY SEAL, FRANK COSTELLO A DECADE OF PROGRESS, H. GENE EVANS PALM BEACH COUNTY'S INTRODUCTION TO SLURRY, CHARLIE HYMAN DEVELOPMENT OF SLURRY SEAL IN THE UNITED KINGDOM, KEITH SHAW THE PROMISE OF SLURRY SEAL, JAMES H.
GARDNER QUALITY, JOHN B. DUNBAR THE DEVELOPMENT OF CATIONIC EMULSIONS IN ARGENTINA, HORACIO C. SALMERI, JULIO RUBINSTEIN SOUTH AMERICA'S MODERN APPROACH TO SLURRY SEAL, TITO KOHNER SANTA BARBARA COUNTY'S SLURRY SEAL PROGRAM, HAROLD R. CALLAHAN.
TRT Terms: Asphalt; Cationic emulsified asphalt; Concrete curing; Elastomer modified asphalt; Frost protection; Quality control; Sales; Slurry; Slurry seals
Other Terms: Curing; Quality; Slurries
Subject Areas: H31 BITUMINOUS MATERIALS AND MIXES; H40 MAINTENANCE, GENERAL
Report Number: 169 pp
TRIS Files: HRIS
Database: TRIS Online

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Date: Tuesday, August 29, 2006

Record **1** of **4** in **TRIS Online** for **kw:"rubberized slurry"**

Title: PAVEMENT PRESERVATION FIGHTS FOR RESPECT
Accession No: 01006922
Authors:
- Kuennen, T

Journal Title:
- Better Roads Vol. 75 No. 9
  http://www.betterroads.com
  Publisher: James Informational Media, Incorporated
  ISSN: 0006-0208 OCLC: 1519687

Corp. Authors / Publisher:
- James Informational Media, Incorporated
  2720 South River Road, Suite 126
  Des Plaines, IL 60018- USA

Publication Date: 20050900
Description: pp 46-56; Figures(1); Photos(11)
Languages: English
Abstract: Pavement preservation, which is the process of repairing road surfaces that will soon fail rather than those that have already fallen apart, has been difficult to sell to road agencies despite the establishment 13 years ago of the Foundation for Pavement Preservation. This article describes why the sub-optimal strategy of "worst-first," often favored by the public and politicians, is so appealing. It also suggests ways for road agencies to jump-start pavement preservation policies. The Federal Highway Administration's Office of Asset Management has recently launched a Pavement Preservation Technical Assistance Program to help agencies define their pavement preservation programs and to build pavement preservation databases. The article also describes in detail pavement preservation initiatives in several cities, as well as the use of rubberized slurry seals.
TRT Terms: Cost effectiveness; Pavement maintenance; Pavement management systems; Preservation; Preventive maintenance; Recycled materials; Slurry seals; Surface course (Pavements)
Subject Areas: H24 PAVEMENT DESIGN AND PERFORMANCE
Availability:
- James Informational Media, Incorporated
  2720 South River Road, Suite 126
  Des Plaines, IL 60018- USA
- Available from UC Berkeley Transportation Library through interlibrary loan or document delivery
  Order Document: http://www.lib.berkeley.edu/ITSL/services.html

URLs: Document: http://www.betterroads.com/articles/sept05f.htm
Document Source:
- UC Berkeley Transportation Library
  Source Data: BTRIS Record Number 6091

TRIS Files: HRIS; BTRIS
Database: TRIS Online

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Date: Tuesday, August 29, 2006

Record **3** of **4** in **TRIS Online** for **kw:"rubberized slurry"**

Title: REDUCING REFLECTION CRACKING IN BITUMINOUS OVERLAYS UTILIZING A STRAIN RELIEVING INTERLAYER OF RUBBERIZED SLURRY
Accession No: 00262804
Authors:
- Stickney, E H

Corp. Authors / Publisher:
- Vermont Department Highways

Publication Date: 19740500
Description: 19 p.; Appendices(5); References(5); Tables
Abstract: Bituminous concrete overlays historically develop reflection cracking during the first winter in Vermont's climatic environment. The degree of severity depends upon several factors such as the first winter's weather, depth of overlay, preparation of the existing pavement and its condition. In an effort to combat the reflection of these cracks, the majority of which are transverse in nature, the Vermont Department of Highways investigated the use of a strain relieving interlayer in the form of a rubberized slurry. After preliminary laboratory investigation, a full-scale field experiment was established in cooperation with the Federal Highway Administration on Interstate Route 91 in the Putney, Vermont area. The results, after the first winter, have proved to be very encouraging. The control section experienced 43 percent reflection whereas the rubber treated areas experienced only 7 and 9 percent. These results were conclusive enough that Vermont will continue to use the strain relieving interlayer concept, in the form of rubberized slurry, in future bituminous concrete overlay projects. /AUTHOR/
TRT Terms: Asphalt concrete; Field tests; Interfaces; Laboratory tests; Overlays (Pavements); Reflection cracking; Rubber; Slurry; Stress relieving
Other Terms: Bituminous concretes; Interlayer spaces; Overlay course; Slurries
Subject Areas: H31 BITUMINOUS MATERIALS AND MIXES; H24 PAVEMENT DESIGN AND PERFORMANCE
Report Number: No. 74-3
TRIS Files: HRIS
Database: TRIS Online

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Date: Wednesday, August 30, 2006

Record **17** of **36** in **TRIS Online** for **kw:slurry kw:rubber**

Title: THE HISTORY, DEVELOPMENT, AND PERFORMANCE OF ASPHALT RUBBER AT ADOT. SPECIAL REPORT. FINAL REPORT

Accession No: 00491745

Authors:
- Scofield, L A

Corp. Authors / Publisher:
- Arizona Department of Transportation
  http://www.dot.state.az.us/
  206 South 17th Avenue
  Phoenix, AZ 85007 USA
- Federal Highway Administration
  http://www.fhwa.dot.gov
  400 7th Street, SW
  Washington, DC 20590 USA

Publication Date: 19891200

Description: 40 p.; Appendices(1); Figures(21); References(14); Tables(17)

Abstract: This report evaluates ADOT's two decades of experience with asphalt-rubber materials. It discusses the chronological development of asphalt rubber by ADOT and the five principle uses of asphalt rubber. The performance of asphalt-rubber materials are determined from historical records and pavement test sections. The performance of asphalt rubber is evaluated by utilizing historical data from ADOT's pavement management system database and by reviewing eight experimental projects which included 47 test sections. Pavement condition distress surveys were performed on several of these projects to determine the terminal condition of the pavements. Asphalt-rubber materials have been placed on over 700 miles of roadway on the State system. This is approximately 10% of ADOT's highway network. Although regularly used on the Interstate System, the principle use has occurred on State and U.S. Routes. The major application has been in mitigating reflective cracking with over 90% of the applications consisting of SAMs and SAMIs. The average life of a SAM is approximately 5 years on the Interstate and 10 years and 8 years for the State and U.S. Routes, respectively. The coefficient of variation in service life ranges between 30%-40% for all three highway classifications. The average life of a SAMI is approximately 9 years for both the Interstate and State Routes while it is only 3 years on the U.S. Routes. Asphalt rubber has successfully been used as an encapsulating membrane to control pavement distortion due to expansive soils and to reduce reflection cracking in overlays on both rigid and flexible pavements. During the 20 years of asphalt rubber use, ADOT has evolved from using slurry applied asphalt-rubber chip seals to utilizing reacted asphalt rubber as a binder in open and dense graded asphalt concrete.

TRT Terms: Asphalt concrete; Asphalt rubber; Binders; Defects; Encapsulation; Energy absorbing materials; Evaluation; Pavement distress; Pavement performance; Pavements; Reflection cracking; Service life; Stresses; Test sections; Traffic mitigation

Other Terms: Asphaltic concrete; Mitigation; Pavement condition; Stress absorbing membrane interlayer; Stress absorbing membranes

Subject Areas: I31 Bituminous binders and materials; H31 BITUMINOUS MATERIALS AND MIXES; I22 Pavement design; H24 PAVEMENT DESIGN AND PERFORMANCE; I23 Properties of road surfaces

Report Number: AZ-SP-8902

Availability:
- National Technical Information Service
  http://www.ntis.gov
  5285 Port Royal Road
  Springfield, VA 22161 USA

TRIS Files: HRIS

Database: TRIS Online

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Date: Tuesday, August 29, 2006

Record **9** of **16** in **TRIS Online** for **kw:rubberized kw:chip kw:seal**

Title: ASPHALT RESEARCH LEADS TO LONGER ROAD LIFE
Accession No: 00477157
Journal Title:

- Better Roads Vol. 58 No. 10
  http://www.betterroads.com
  Publisher: James Informational Media, Incorporated
  ISSN: 0006-0208 OCLC: 1519687

Corp. Authors / Publisher:

- James Informational Media, Incorporated
  2720 South River Road, Suite 126
  Des Plaines, IL 60018- USA

Publication Date: 19881000
Description: p. 18-20; Figures; Photos
Abstract: Addition of just 3% of styrene butadiene rubber latex (SBR) will at least double the viscosity of most asphalt cements, providing rutting and shoving remedies. A typical AC-20 (absolute viscosity of 2,000 poise) will increase in viscosity to about the 4,000 to 4,500 poise range with the addition of the material. This greatly increases the toughness of the AC binder. SBR latex also increases the softening point of the AC by 10 to 15 degrees F, allowing it to withstand more heat before deforming. It enhances the elastic recovery of the asphalt. The increased viscosity is achieved, however, without losing cold weather ductility or adhesion to the aggregates. Thus, thermal cracking and stripping is reduced, and chip seal adhesion is improved.
TRT Terms: Adhesion; Chip seals; Cracking; Ductility; Rubberized bitumen; Stripping (Pavements); Thermal stresses
Other Terms: Stripping; Thermal fracture
Subject Areas: I31 Bituminous binders and materials; H31 BITUMINOUS MATERIALS AND MIXES
TRIS Files: HRIS
Database: TRIS Online

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Date: Tuesday, August 29, 2006

Record **3** of **16** in **TRIS Online** for **kw:rubberized kw:chip kw:seal**

Title: CALIFORNIA PUTS FOAMED ASPHALT TO THE TEST
Accession No: 00961160
Authors:
- Kuennen, T

Journal Title:
- Better Roads Vol. 73 No. 7
  http://www.betterroads.com
  Publisher: James Informational Media, Incorporated
  ISSN: 0006-0208 OCLC: 1519687

Corp. Authors / Publisher:
- James Informational Media, Incorporated
  2720 South River Road, Suite 126
  Des Plaines, IL 60018- USA

Publication Date: 20030700
Description: p. 16-19; Photos(2)
Languages: English
Abstract: The rural roads in California's Delta region are built on alluvium that is always shifting, making it prohibitively expensive to repair them with conventional means. The California Department of Transportation (Caltrans) is experimenting with foamed or expanded asphalt used along with in-place base recycling. One stretch of road was near complete failure in late 2002, so it became a testing ground for the new method. Conventional reconstruction would have meant very limited life, but cold foaming gives another 10 years of operability. The expanded asphalt forms a mortar or glue that bonds particles. The technology sidesteps several aspects of conventional asphalt such as the use of solvents and the time waiting for the break for emulsions. The road was treated in two passes with the initial foamed surface compacted then rough-graded, compacted again and find graded. A rubberized chip seal was to be placed as a driving surface. It can carry traffic immediately. The project has served to introduce local agencies to the process.

Supplemental Information:
- Special Recycling Section

TRT Terms: Asphalt pavements; Cost effectiveness; Expanded materials; Foamed asphalt; Recycled materials
Geographical Terms:
California
Other Terms: In-place base recycling
Subject Areas: H31 BITUMINOUS MATERIALS AND MIXES
Availability:
- James Informational Media, Incorporated
  2720 South River Road, Suite 126
  Des Plaines, IL 60018- USA
- Available from UC Berkeley Transportation Library through interlibrary loan or document delivery
  Order Document: http://www.lib.berkeley.edu/ITSL/services.html

URLs: Document: http://www.betterroads.com/articles/jul03a.htm
Document Source:
- UC Berkeley Transportation Library
  Source Data: BTRIS Record Number 3302

TRIS Files: HRIS; BTRIS
Database: TRIS Online

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Date: Tuesday, August 29, 2006

Record **12** of **16** in **TRIS Online** for **kw:rubberized kw:chip kw:seal**

Title: CHARACTERISTICS AND PERFORMANCE OF ASPHALT-RUBBER MATERIAL CONTAINING A BLEND OF RECLAIM AND CRUMB RUBBER
Accession No: 00348700

Authors:
- Huff, B J
- Vallerga, B A

Journal Title:
- Transportation Research Record No. 821
  Publisher: Transportation Research Board
  ISSN: 0361-1981

Corp. Authors / Publisher:
- Transportation Research Board
  http://trb.org
  500 Fifth Street, NW
  Washington, DC 20001 USA

Publication Date: 19810000

Description: p. 29-37; Figures(4); References(12); Tables(4)

Abstract:
Asphalt cement, rubber extender oil, and a mixture of ground reclaim and crumb rubber, blended together at an elevated temperature in specific proportions and sequences, form a tough, durable, and adhesive membrane when hot-spray-applied to a surface and allowed to cool to ambient temperatures. This cast-in-place asphalt-rubber membrane has been found to be suitable for use in the construction of surface treatments for existing pavements (chip seals), stress-absorbing membrane interlayers (SAMIs) in the placing of asphalt concrete overlays, and waterproofing membranes for bridge decks and hydraulic linings (ponds, canals, and reservoirs). When hot-poured into pavement joints and cracks and allowed to cool, it also serves as an effective joint and crack filler. The concepts and proportions of the formulation and preparation of this material are presented together with information and data on its properties and applications. A discussion is presented of the results of two analytic studies on the applicability of asphalt-rubber membranes (a) in minimizing reflection cracking when used as a SAMI and (b) in producing a "multilayered aggregate structure" when used as a single-pass chip seal. A summary of the field performance observed to date on a number of installations of the asphalt-rubber material in its various applications is also included, together with observations on the efficacy of the material as a membrane and as a filler. (Authors)

Supplemental Information:
This paper appeared in TRB Record 821, Bituminous Mixes, Concrete Pavements and Structures, Testing, and Construction Prices.

TRT Terms: Asphalt cement; Chip seals; Cracking; Joint sealers; Overlays (Pavements); Pavement performance; Reclaimed rubber; Reflection cracking; Rubberized bitumen; Sprayers; Surface treating; Waterproofing materials

Other Terms: Cracks; Membrane; Membranes (Biology); Overlay course; Spraying; Stress control; Surface treatment

Subject Areas: I31 Bituminous binders and materials; H31 BITUMINOUS MATERIALS AND MIXES; H24 PAVEMENT DESIGN AND PERFORMANCE

Availability:
- Transportation Research Board Business Office
  500 Fifth Street, NW
  Washington, DC 20001 USA
  Order Document: http://nationalacademies.org/trb/publications/tris/out_of_print.html

TRIS Files: HRIS

Database: TRIS Online

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Date: Tuesday, August 29, 2006

Record **10** of **16** in **TRIS Online** for **kw:rubberized kw:chip kw:seal**

Title: CRUMB RUBBER CHIP SEAL EAST OF PUNKIN CENTER. FINAL REPORT
Accession No: 00458343
Authors:
- LaForce, R F

Corp. Authors / Publisher:
- Colorado Department of Highways
  4201 East Arkansas Avenue
  Denver, CO 80222 USA
- Federal Highway Administration
  http://www.fhwa.dot.gov
  400 7th Street, SW
  Washington, DC 20590 USA

Publication Date: 19860300
Description: 26 p.
Abstract: This report documents the performance of rubber asphalt binders as chip seal materials. The test sections consisted of two rubber-asphalt binders, a rubberized cutback (RC-800, the standard chip seal at the time of construction), and a plain AC-10 chip seal. At the end of the evaluation period, the rubber asphalt binders had performed as well as the rubberized RC-800; however, from an economic standpoint the rubberized RC-800 is recommended for use as a chip seal binder on low-volume highway. Since construction of this project, other CDOH studies have shown emulsified polymerized asphalt binders performed as well or better than the RC-800 rubberized material at an additional savings.
TRT Terms: Alternatives analysis; Bituminous binders; Chip seals; Cost effectiveness; Crumb rubber; Experimental roads; Liquid asphalt; Low volume roads; Pavement performance; Polymer asphalt; Rubberized bitumen
Other Terms: Comparison; Cut back; Experimental pavements
Subject Areas: I31 Bituminous binders and materials; H31 BITUMINOUS MATERIALS AND MIXES; H34 GENERAL MATERIALS; H40 MAINTENANCE, GENERAL; H24 PAVEMENT DESIGN AND PERFORMANCE
Report Number: CDOH-DTP-R-86-3
Availability:
- National Technical Information Service
  http://www.ntis.gov
  5285 Port Royal Road
  Springfield, VA 22161 USA

Document Source:
- Federal Highway Administration
  http://www.fhwa.dot.gov
  400 7th Street, SW
  Washington, DC 20590 USA

TRIS Files: HRIS
Database: TRIS Online

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Transportation Research Board
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Date: Tuesday, August 29, 2006

Record **5** of **16** in **TRIS Online** for **kw:rubberized kw:chip kw:seal**

Title: DELAMINATION SURVEYS AND REMOVAL PROCEDURES FOR RUBBERIZED ASPHALT CHIP SEAL (RACS) BRIDGE DECK OVERLAYS
Accession No: 00921533
Authors:
- Jenkins, CHM

Period Covered: 9705-9807
Corp. Authors / Publisher:
- South Dakota School of Mines and Technology
  Mechanical Engineering Department, 500 East St Joseph Street
  Rapid City, SD 57701 USA
  South Dakota Department of Transportation
  http://www.state.sd.us/dot/
  700 Broadway Avenue East
  Pierre, SD 57501 USA

Publication Date: 19980700
Description: 32 p.; Photos(12); Tables(4)
Languages: English
Abstract: Rubberized Asphalt Chip Seal (RACS) has been used for several decades to protect the bridges in South Dakota. RACS, among other things, prevents South Dakota Department of Transportation from evaluating the integrity of the bridge decks in an efficient and accurate manner. This study investigated methods to remove the RACS layer from the bridges in South Dakota. The procedure followed during the investigation was to first examine numerous options available for RACS removal. These were organized into a "decision matrix" and a formal procedure was followed to extract the most likely candidate methods for further investigation, namely, scraping, high pressure washing, and melting. Scraping with heating was deemed to be the method with the most potential for success, and a full-scale field test was conducted on an I-90 bridge deck. The report concludes with a recommended implementation procedure.
TRT Terms: Asphalt rubber; Bridge decks; Chip seals; Field tests; Implementation; Recommendations
Geographical Terms: South Dakota
Other Terms: Overlay removal; Overlays (Bridge decks); Scraping with heating
Subject Areas: I61 Equipment and maintenance methods; H40 MAINTENANCE, GENERAL
Contract Number: 310543
Report Number: SD96-19-F,; Final Report
Availability:
- South Dakota Department of Transportation
  http://www.state.sd.us/dot/
  700 Broadway Avenue East
  Pierre, SD 57501 USA

URLs: Document: http://ntl.bts.gov/lib/20000/20900/20908/PB98157811.pdf
Document: http://www.state.sd.us/Applications/HR19ResearchProjects/Projects/SD1996_19_final_report.pdf
TRIS Files: HRIS
Database: TRIS Online

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Date: Tuesday, August 29, 2006

Record **13** of **16** in **TRIS Online** for **kw:rubberized kw:chip kw:seal**

Title: FOLLOW UP REPORT ON DEMONSTRATION PROJECT 1-10-76-526 "EVALUATION OF OVERFLEX PAVEMENTS TEST SECTIONS" (53 MO.)
Accession No: 00349785

Authors:
- Hankins, K D

Corp. Authors / Publisher:
- Texas State Department of Highways & Public Transp
  P.O. Box 5051
  Austin, TX 78763 USA
- Federal Highway Administration
  http://www.fhwa.dot.gov
  400 7th Street, SW
  Washington, DC 20590 USA

Publication Date: 19810600
Description: 12 p.
Abstract: This report describes the 53 month observations of several binder types used in penetration or chip seal coat type construction. Originally it was desired to place and observe a tire rubber-asphalt section but other binders were also included. After 53 months several areas are in need of rehabilitation and very little difference can be observed between binder types. This will be the last observation period. (FHWA)
TRT Terms: Binder course; Bituminous pavements; Chip seals; Demonstration projects; Experimental roads; Rubberized bitumen; Tires
Other Terms: Experimental pavements
Subject Areas: I31 Bituminous binders and materials; H31 BITUMINOUS MATERIALS AND MIXES; H34 GENERAL MATERIALS; I22 Pavement design; H24 PAVEMENT DESIGN AND PERFORMANCE; I23 Properties of road surfaces
Contract Number: 1-10-77-187
Report Number: FHWA/TX-81/33+187-7 Intrm Rpt.

Availability:
- National Technical Information Service
  http://www.ntis.gov
  5285 Port Royal Road
  Springfield, VA 22161 USA

TRIS Files: HRIS
Database: TRIS Online

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Date: Tuesday, August 29, 2006

Record **2** of **16** in **TRIS Online** for **kw:rubberized kw:chip kw:seal**

Title: OTTA SEALS AND GRAVSEALS AS LOW-COST SURFACING ALTERNATIVES FOR LOW-VOLUME ROADS: EXPERIENCES IN SOUTH AFRICA
Accession No: 00942554

Authors:
- Oloo, S
- Lindsay, R
- Mothilal, S

Conference Title:
- Eighth International Conference on Low-Volume Roads
  Date Held: 20030622 - 20030625
  Reno, Nevada
  Sponsoring Agency:
  Federal Highway Administration; USDA Forest Service; U.S. Army Corps of Engineers; Bureau of Indian Affairs; University of Nevada, Reno; Costa Rica University; Nevada Department of Transportation; and Transportation Research Board.

Journal Title:
- Transportation Research Record No. 1819
  Publisher: Transportation Research Board
  ISSN: 0361-1981

Corp. Authors / Publisher:
- Transportation Research Board
  http://trb.org
  500 Fifth Street, NW
  Washington, DC 20001 USA

Publication Date: 20030000
Description: p. 338-342; Figures(4); References(4); Tables(1)
Languages: English

Abstract: The geology of the northeastern part of the province of KwaZulu-Natal, South Africa, is predominantly alluvial with vast deposits of sands. Suitable gravel sources are hard to come by, which results in high graveling and regraveling costs brought about by long haul distances and accelerated gravel loss. Most gravel roads carry fewer than 500 vehicles per day of which less than 10% are heavy vehicles. The high cost of regraveling has led to consideration of upgrading such roads to surfaced standard, even though traffic volumes do not justify upgrading. Traditional chip seals are expensive and cannot be economically justified on roads that carry fewer than 500 vehicles per day. The KwaZulu-Natal Department of Transport is actively involved in efforts to identify cost-effective alternative surfacing products for low-volume roads. Field trials were conducted with Otta seals and Gravseals, which have been used successfully in other countries, as low-cost surfacing products for low-volume roads. The Otta seal is formed by placing graded aggregates on a relatively thick film of soft binder that, because of traffic and rolling, works its way through the aggregates. Gravseal consists of a special semipriming rubberized binder that is covered by a graded aggregate. Both Otta seals and Gravseals provide relatively flexible bituminous surfaces suitable for low-volume roads. Cost savings are derived mainly from the broad aggregate specifications, which allow for the use of marginal materials.

Supplemental Information:
This paper appears in Transportation Research Record No. 1819, Volume 2, Eighth International Conference on Low-Volume Roads 2003.

TRT Terms: Cost effectiveness; Field tests; Low volume roads; Seal coats
Geographical Terms: KwaZulu-Natal (South Africa); South Africa
Other Terms: Gravseals; Marginal materials; Otta seals
Subject Areas: I22 Pavement design; H24 PAVEMENT DESIGN AND PERFORMANCE; I23 Properties of road surfaces
ISBN: 0309077486

Availability:
- Transportation Research Board Business Office
  500 Fifth Street, NW
  Washington, DC 20001 USA
  Order Document: http://trb.org/news/blurb_detail.asp?id=1623

TRIS Files: HRIS
Database: TRIS Online

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Date: Tuesday, August 29, 2006

Record **1** of **16** in **TRIS Online** for **kw:rubberized kw:chip kw:seal**

Title: POLYMERS ADD PERFORMANCE TO ASPHALT EMULSIONS
Accession No: 00982315
Authors:
- Kuennen, T

Journal Title:
- Better Roads Vol. 74 No. 11
  http://www.betterroads.com
  Publisher: James Informational Media, Incorporated
  ISSN: 0006-0208 OCLC: 1519687

Corp. Authors / Publisher:
- James Informational Media, Incorporated
  2720 South River Road, Suite 126
  Des Plaines, IL 60018- USA

Publication Date: 20041100
Description: p. 28-37; Photos(12)
Languages: English
Abstract: This article reviews how plastic, or polymer, and rubber additives can provide asphalt chip seals with longevity and the ability to withstand heavy traffic. It describes surface treatments such as polymer- modified asphalt emulsions, which can be elastomeric or plastomeric, and highfloat emulsions. Rubberized asphalt chip seals, in which ground rubber tires are blended with hot liquid asphalt cement, are used to absorb stress and help reduce reflection cracking. Slurry surfacing or slurry seals are a mix of aggregates in an asphalt emulsion which are then applied in a slurry state and yield surfaces that have a smooth finish and high skid resistance. Aggregate and binder are incompatible and can lead to chip seal failure. The article describes a new test protocol that has been developed which may allow for more predictable chip seal performance. It also lists a number of recommendations from a study which showed that chip seals can be effectively used on high-volume roads.
TRT Terms: Asphalt emulsions; Asphalt pavements; Bituminous binders; Chip seals; Pavement performance; Polymers; Slurry seals
Subject Areas: H31 BITUMINOUS MATERIALS AND MIXES
Availability:
- James Informational Media, Incorporated
  2720 South River Road, Suite 126
  Des Plaines, IL 60018- USA
  Available from UC Berkeley Transportation Library through interlibrary loan or document delivery
  Order Document: http://www.lib.berkeley.edu/ITSL/services.html

URLs: Document: http://www.betterroads.com/articles/nov04f.htm
Document Source:
- UC Berkeley Transportation Library
  Source Data: BTRIS Record Number 5042

TRIS Files: HRIS; BTRIS
Database: TRIS Online

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Date: Tuesday, August 29, 2006

Record **6** of **16** in **TRIS Online** for **kw:rubberized kw:chip kw:seal**

Title: PROGRAM PINPOINTS BEST ALTERNATIVES FOR COST-EFFECTIVE ROAD MAINTENANCE
Accession No: 00735840
Authors:
- Freeman, T

Journal Title:
- Texas Transportation Researcher Vol. 32 No. 4
  Publisher: Texas Transportation Institute
  ISSN: 0040-4748 OCLC: 1587330

Corp. Authors / Publisher:
- Texas Transportation Institute
  http://tti.tamu.edu/
  Texas A&M University 1600 E Lamar Boulevard, Suite 120
  Arlington, TX 76011 USA
- Texas Transportation Institute
  http://www.tti.tamu.edu
  The Texas A&M University System
  College Station, TX 77843-3135 USA

Publication Date: 19970000
Description: p. 10; Photos(2)
Languages: English
Abstract: The Supplemental Maintenance Effectiveness Research Program (SMERP) of the Texas Transportation Institute was designed to analyze the cost-effectiveness of various maintenance alternatives, with the goal of determining the most efficient ways to preserve Texas roads. SMERP was originally established as a supplemental study to the Strategic Highway Research Program. Six types of pavement treatments are being studied at 20 sites including rubberized chip seal, polymer-modified emulsion chip seal, latex-modified asphalt chip seal, asphalt chip seal, microsurfacing treatment, and fog seal. This brief article highlights the ongoing SMERP tests and the preliminary results to date.
TRT Terms: Chip seals; Cost effectiveness; Pavement performance; Preventive maintenance; Research; Surface treating
Identifier Terms: Strategic Highway Research Program
Other Terms: Fog seal; Microsurfacing; Surface treatments
Subject Areas: I22 Pavement design; H24 PAVEMENT DESIGN AND PERFORMANCE; I23 Properties of road surfaces
Availability:
- Texas Transportation Institute
  http://tti.tamu.edu/
  Texas A&M University 1600 E Lamar Boulevard, Suite 120
  Arlington, TX 76011 USA

TRIS Files: HRIS
Database: TRIS Online

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Date: Tuesday, August 29, 2006

Record **7** of **16** in **TRIS Online** for **kw:rubberized kw:chip kw:seal**

Title: RUBBERIZED ASPHALT -- STILL SOUND AFTER 20 YEARS
Accession No: 00615016
Authors:

- Charania, E
- Cano, J O
- Schnormeier, R H

Journal Title:

- Better Roads Vol. 61 No. 8
  http://www.betterroads.com
  Publisher: James Informational Media, Incorporated
  ISSN: 0006-0208 OCLC: 1519687

Corp. Authors / Publisher:

- James Informational Media, Incorporated
  2720 South River Road, Suite 126
  Des Plaines, IL 60018- USA

Publication Date: 19910800
Description: p. 35
Abstract: This article describes how the city of Phoenix, Arizona has successfully used asphalt-rubber chip seal in its pavement management system since the mid 1960s. Phoenix has used asphalt-rubber in two types of surface treatments; one, Stress Absorbing Membrane (SAM), where a hot asphalt-rubber chip seal was applied to the distressed cracked surface. The second was Stress Absorbing Membrane Interlayer (SAMI). In this form of treatment, a hot asphalt-rubber chip seal is applied to the surface and is followed by a 1.5- to 2.0-in. asphalt concrete overlay.
TRT Terms: Asphalt cement; Asphalt mixtures; Asphalt pavements; Asphalt rubber; Overlays (Pavements); Pavement management systems; Thickness
Other Terms: Asphaltic mixtures; Overlay thickness
Subject Areas: H31 BITUMINOUS MATERIALS AND MIXES; H40 MAINTENANCE, GENERAL
Availability:

- Better Roads
  P.O. Box 558
  Park Ridge, IL 60068 USA

TRIS Files: HRIS
Database: TRIS Online

National Transportation Library - Search Result

TRIS Online • TRT • NTL Catalogs
NTL Integrated Search
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Date: Tuesday, August 29, 2006

Record **16** of **16** in **TRIS Online** for **kw:rubberized kw:chip kw:seal**

Title: SOUTH DAKOTA CHIP SEAL COAT STUDY
Accession No: 00211356
Authors:
- Crawford, R A

Corp. Authors / Publisher:
- South Dakota Department of Highways
  Physical Research Section
  Pierre, SD 57501 USA

Publication Date: 19670000
Description: 43 p.; Appendices(1); Figures; Tables
Abstract: THIS STUDY IS CONCERNED WITH THE COMPARISON AND EVALUATION OF CHIP SEAL COATS PLACED USING AN RS-2 EMULSIFIED ASPHALT, AN RC-4 CUTBACK ASPHALT AND SEVERAL RUBBERIZED RC-4 ASPHALTS. ALL COMPARISONS AND THE EVALUATION ARE BASED ON RATINGS DETERMINED BY THE SOUTH DAKOTA SEAL COAT EVALUATION PROCEDURE. THE RS-2 CHIP SEAL COATS DID NOT PERFORM AS WELL AS THE RC-4 AND RUBBERIZED PROJECTS. THE ADDITION OF RUBBER TO ASPHALT OF THE TYPE USED IN SOUTH DAKOTA FROM 1956 TO 1959 DOES NOT IMPROVE EITHER THE QUALITY OR LIFE EXPECTANCY OF CHIP SEALS. FOR THIS REASON RUBBERIZED ASPHALTS ARE NOT CONSIDERED TO BE ECONOMICALLY FEASIBLE AT THE PRESENT TIME. OTHER OBSERVATIONS CONCERNING CHIP SEAL PERFORMANCE WERE MADE DURING THE STUDY. IT IS CONCLUDED THAT CONSTRUCTION CONTROL, WEATHER, EQUIPMENT AND THE EXPERIENCE OF CONSTRUCTION PERSONNEL ARE VARIABLES WHICH APPARENTLY HAVE MORE PROFOUND EFFECTS ON A SEAL COAT THAN THE TYPE OF ASPHALT USED. /AUTHOR/
TRT Terms: Chippings; Construction equipment; Construction management; Elastomer modified asphalt; Emulsified asphalt; Evaluation; Liquid asphalt; Performance; Seal coats; Weather
Other Terms: Chips; Construction control
Subject Areas: H31 BITUMINOUS MATERIALS AND MIXES
Report Number: Final Report
TRIS Files: HRIS
Database: TRIS Online

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NTL Integrated Search
National Transportation Library

Transportation Research Board
Of the National Academies

Date: Tuesday, August 29, 2006

Record **11** of **16** in **TRIS Online** for **kw:rubberized kw:chip kw:seal**

Title: SQUEEGEE SEAL AND CRUMB RUBBER CHIP SEAL, SAPINERO-EAST. FINAL REPORT
Accession No: 00468644

Authors:
- LaForce, R F

Corp. Authors / Publisher:
- Colorado Department of Highways
  4201 East Arkansas Avenue
  Denver, CO 80222 USA
- Federal Highway Administration
  http://www.fhwa.dot.gov
  400 7th Street, SW
  Washington, DC 20590 USA

Publication Date: 19831100
Description: 38 p.
Abstract: A severely cracked section of asphalt pavement located in South Central Colorado was overlayed with materials intended to prevent reflection cracking. Construction features included a squeegee seal, plant mix leveling course and a rubber asphalt chip seal. Five years of performance were evaluated as part of this study with recommendations for treatment of reflection cracking.
TRT Terms: Chip seals; Construction management; Performance evaluations; Prevention; Reflection cracking; Rubberized bitumen
Other Terms: Construction operations
Subject Areas: H33 CONSTRUCTION; I52 Construction of pavements and surfacings; I61 Equipment and maintenance methods; H40 MAINTENANCE, GENERAL; I22 Pavement design; H24 PAVEMENT DESIGN AND PERFORMANCE
Report Number: CDOH-DTP-R-83-13

Availability:
- National Technical Information Service
  http://www.ntis.gov
  5285 Port Royal Road
  Springfield, VA 22161 USA
  Order Number: PB86-128055/XAB

Document Source:
- National Technical Information Service
  http://www.ntis.gov
  5285 Port Royal Road
  Springfield, VA 22161 USA

TRIS Files: HRIS
Database: TRIS Online

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NTL Integrated Search
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Date: Tuesday, August 29, 2006

Record **15** of **16** in **TRIS Online** for **kw:rubberized kw:chip kw:seal**

Title: SUMMARY OF WORKSHOP SESSION ON SURFACE SEALING--DENVER, COLORADO
Accession No: 00792295

Authors:
- Sayre, C A

Conference Title:
- Water in Pavements Workshop--Detailed Report--1973

Corp. Authors / Publisher:
- Federal Highway Administration
  http://www.fhwa.dot.gov/
  Office of Research, Development, Engineering and Highway Operations, 400 7th Street, SW
  Washington, DC 20590 USA

Publication Date: 19730000
Description: p. 384-386
Languages: English

Abstract:
This paper summarizes the work session on surface sealing held at the 1973 Federal Highway Administration workshop on Water in Pavements in Denver, Colorado. Kansas has a very intense crack-sealing program underway on their highways using a cationic emulsion. Texas does some crack-sealing, but they tend to lean toward seal coats and overlays to seal pavement cracks. Colorado has used a method where a coat of emulsion is sprayed on the roadway surface and a motor grader with a rubber squeegee attached to the grader blade spreads the emulsion back and forth across the roadway, forcing it into the cracks. New Mexico has tried using a combination of CRS-1 emulsion and approximately 10% rubberized-latex additive. In the southeast portion of New Mexico, an asphalt hot-mix of crusher fines and 120-150 penetration asphalt cement is worked back and forth across the roadway and rolled at the same time, forcing it into the surface cracks. The most general method of crack sealing in New Mexico is that of filling the crack with an MC type asphalt and blotting it with sand or other fine material. Various methods of surface sealing were discussed, including the heater-scarifier method of rejuvenating old asphalt pavements ahead of an asphalt hot-mix overlay. The use of ground rubber in asphalt used in chip sealing was briefly discussed. None of the states were using a slurry seal. However, most states have been using cat-blown asphalt for shoulder sealing and problem areas.

Supplemental Information:
This paper was presented at a 1973 workshop on Water in Pavements sponsored by the Federal Highway Administration, held in Denver, Colorado.

TRT Terms: Asphalt emulsions; Chip seals; Graders; Heaters; Hot mix paving mixtures; Overlays (Pavements); Pavement cracking; Pavement maintenance; Pavements; Road shoulders; Scarifying; Seal coats; Sealing (Technology); Slurry seals; Surface course (Pavements); Workshops

Geographical Terms: Colorado; Kansas; New Mexico; Texas

Subject Areas: H33 CONSTRUCTION; I52 Construction of pavements and surfacings; I61 Equipment and maintenance methods; H40 MAINTENANCE, GENERAL; I22 Pavement design; H24 PAVEMENT DESIGN AND PERFORMANCE

Availability:
- Federal Highway Administration
  http://www.fhwa.dot.gov/
  Office of Research, Development, Engineering and Highway Operations, 400 7th Street, SW
  Washington, DC 20590 USA

TRIS Files: HRIS
Database: TRIS Online

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Date: Tuesday, August 29, 2006

Record **8** of **16** in **TRIS Online** for **kw:rubberized kw:chip kw:seal**

Title: THE EFFECTS OF INCREASED SALT USAGE ON THE CHLORIDE CONCENTRATION IN SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION BRIDGES AND ROADS
Accession No: 00600785
Authors:
- Marks, K E

Corp. Authors / Publisher:
- South Dakota Department of Transportation
  http://www.state.sd.us/dot/
  Research Program, 700 E Broadway Avenue
  Pierre, SD 57501 USA

Publication Date: 19900501
Description: 9 p.; Appendices(2); Figures(4)
Abstract: After passage of law HB 1162 in 1988, which created a winter safe highway maintenance program including a special fund to be used for the increased salting of State highways and bridges, the South Dakota Department of Transportation developed a policy and standards to apply more salt for the increased removal of snow and ice. While implementing the policy, a project was conducted to see what effect the increased use of salt would have on South Dakota's bridges and highways. Fifty-three bridges of three types and 19 sections of highways were sampled. Each of the bridge or highway sections had eight samples removed for analysis. The first samples were taken in the fall of 1988 and the second set in the summer of 1989. The samples were checked for chloride concentration by Atomic Absorption Spectroscopic Analysis. Results indicated that the increased use of salt has significantly increased the chloride concentration of the bridges in this study. It was found that, while it is next to impossible to decrease the salt concentration, a rubberized asphalt chip seal on bridges is an effective method of keeping new salt from being introduced into the bridge. Results from the highway sections showed that the increased use of salt has had very little determinable effect.
TRT Terms: Asphalt rubber; Bridges; Chip seals; Highways; Impacts; Measures of effectiveness; Snow and ice control; Sodium chloride; Utilization
Geographical Terms: South Dakota
Other Terms: Effectiveness; Increase; Salt (Sodium chloride); Snow & ice control
Subject Areas: H40 MAINTENANCE, GENERAL; I62 Winter maintenance
Availability:
- South Dakota Department of Transportation
  http://www.state.sd.us/dot/
  Research Program, 700 E Broadway Avenue
  Pierre, SD 57501 USA

TRIS Files: HRIS
Database: TRIS Online

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Date: Wednesday, August 30, 2006

Record **17** of **36** in **TRIS Online** for **kw:slurry kw:rubber**

Title: THE HISTORY, DEVELOPMENT, AND PERFORMANCE OF ASPHALT RUBBER AT ADOT. SPECIAL REPORT. FINAL REPORT
Accession No: 00491745
Authors:
- Scofield, L A

Corp. Authors / Publisher:
- Arizona Department of Transportation
  http://www.dot.state.az.us/
  206 South 17th Avenue
  Phoenix, AZ 85007 USA
- Federal Highway Administration
  http://www.fhwa.dot.gov
  400 7th Street, SW
  Washington, DC 20590 USA

Publication Date: 19891200
Description: 40 p.; Appendices(1); Figures(21); References(14); Tables(17)
Abstract: This report evaluates ADOT's two decades of experience with asphalt-rubber materials. It discusses the chronological development of asphalt rubber by ADOT and the five principle uses of asphalt rubber. The performance of asphalt-rubber materials are determined from historical records and pavement test sections. The performance of asphalt rubber is evaluated by utilizing historical data from ADOT's pavement management system database and by reviewing eight experimental projects which included 47 test sections. Pavement condition distress surveys were performed on several of these projects to determine the terminal condition of the pavements. Asphalt-rubber materials have been placed on over 700 miles of roadway on the State system. This is approximately 10% of ADOT's highway network. Although regularly used on the Interstate System, the principle use has occurred on State and U.S. Routes. The major application has been in mitigating reflective cracking with over 90% of the applications consisting of SAMs and SAMIs. The average life of a SAM is approximately 5 years on the Interstate and 10 years and 8 years for the State and U.S. Routes, respectively. The coefficient of variation in service life ranges between 30%-40% for all three highway classifications. The average life of a SAMI is approximately 9 years for both the Interstate and State Routes while it is only 3 years on the U.S. Routes. Asphalt rubber has successfully been used as an encapsulating membrane to control pavement distortion due to expansive soils and to reduce reflection cracking in overlays on both rigid and flexible pavements. During the 20 years of asphalt rubber use, ADOT has evolved from using slurry applied asphalt-rubber chip seals to utilizing reacted asphalt rubber as a binder in open and dense graded asphalt concrete.
TRT Terms: Asphalt concrete; Asphalt rubber; Binders; Defects; Encapsulation; Energy absorbing materials; Evaluation; Pavement distress; Pavement performance; Pavements; Reflection cracking; Service life; Stresses; Test sections; Traffic mitigation
Other Terms: Asphaltic concrete; Mitigation; Pavement condition; Stress absorbing membrane interlayer; Stress absorbing membranes
Subject Areas: I31 Bituminous binders and materials; H31 BITUMINOUS MATERIALS AND MIXES; I22 Pavement design; H24 PAVEMENT DESIGN AND PERFORMANCE; I23 Properties of road surfaces
Report Number: AZ-SP-8902
Availability:
- National Technical Information Service
  http://www.ntis.gov
  5285 Port Royal Road
  Springfield, VA 22161 USA

TRIS Files: HRIS
Database: TRIS Online

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Date: Tuesday, August 29, 2006

Record **14** of **16** in **TRIS Online** for **kw:rubberized kw:chip kw:seal**

Title: THE STATE-OF-THE-PRACTICE IN COLORADO--PART I
Accession No: 00792286
Authors:
- Whalin, B

Conference Title:
- Water in Pavements Workshop--Detailed Report--1973

Corp. Authors / Publisher:
- Federal Highway Administration
  http://www.fhwa.dot.gov/
  Office of Research, Development, Engineering and Highway Operations, 400 7th Street, SW
  Washington, DC 20590 USA

Publication Date: 19730000
Description: p. 347-350
Languages: English
Abstract: This paper outlines Colorado's laboratory pavement design procedure as it relates to moisture susceptible aggregates and protecting the subgrade from the intrusion of moisture through the pavement. The state's flexible pavement design procedure is a modification of American Society for Testing and Materials (ASTM) 1561, which is the molding of stabilometer test specimens using the kneeding compactor, a modification of ASTM 1562, which addresses itself to the testing of the molded specimens in the stabilometer and the cohesiometer, and modifications of ASTM D1074 and D1075, which respectively are the compressive strength of bituminous mixtures and the effect of water on cohesion of compacted bituminous mixtures. Other standard tests run include the centrifuge-kerosene equivalent procedure for the estimated optimum asphalt content and the maximum specific gravity of the loose bituminous mixture. Three common methods are used for upgrading moisture sensitive aggregates to meet the criterion of index of retained strength: using a no-strip type additive in the asphalt, adding hydrated lime with moisture into the stockpiled aggregate, and adding dry hydrated lime to the hot aggregate. Colorado uses catalytically blown asphalt membranes through cuts of swelling shale. The state has also been using more full-depth asphalt pavements directly on subgrade soils. The use of emulsified-asphalt-treated base is common, both in the fine sands and in the typical minus 0.75-in. (1.9-cm) aggregate. To protect the surface of the finished pavements from the intrusion of water, they use open-graded and medium-graded plant-mix seal coats. They use some chip-seal coats--mostly rubberized reinforced concrete liquid asphalts. They also use rejuvenating agents on both new and old pavements. The only treatment directed at inhibiting the intrusion of moisture into the subgrade of rigid pavements is the use of emulsified-treated bases. Colorado's emphasis is on good geometric design, good quality concrete, and proper finishing and curing of concrete.

Supplemental Information:
This paper was presented at a 1973 workshop on Water in Pavements sponsored by the Federal Highway Administration, held in Denver, Colorado.

TRT Terms: Aggregates; Asphalt additives; Base course (Pavements); Bituminous mixtures; Calcium hydroxide; Chip seals; Concrete; Concrete curing; Concrete finishing; Emulsified asphalt; Geometric design; Impervious membranes; Laboratory tests; Mix design; Moisture barriers; Open graded aggregates; Pavement design; Plant mix; Quality assurance; Rigid pavements; Seal coats; State of the practice; Subgrade (Pavements)

Geographical Terms:
Colorado

Identifier Terms: American Society for Testing and Materials
Subject Areas: I22 Pavement design; H24 PAVEMENT DESIGN AND PERFORMANCE
Availability:
- Federal Highway Administration
  http://www.fhwa.dot.gov/
  Office of Research, Development, Engineering and Highway Operations, 400 7th Street, SW
  Washington, DC 20590 USA

TRIS Files: HRIS
Database: TRIS Online

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Date: Wednesday, August 30, 2006

Record **3** of **36** in **TRIS Online** for **kw:slurry kw:rubber**

Title: THIN TREATMENTS EXTEND ROAD LIFE AND BUDGET
Accession No: 00792329
Authors:
- Couret, C

Journal Title:
- American City and County Vol. 115 No. 5
  Publisher: Intertec Publishing Corporation
  ISSN: 0149-337X

Corp. Authors / Publisher:
- Intertec Publishing Corporation
  6151 Powers Ferry Road, NW
  Atlanta, GA 30339-2941 USA

Publication Date: 20000400
Description: 2 p.; Photos(1)
Languages: English
Abstract: By using asphalt-rubber repair techniques and other "thin" resurfacing treatments, the Rhode Island Department of Transportation (RIDOT) has been able to add life to existing pavement and expects to save money on repairs and labor. Preservation activities usually take place on roads that are 5-10 years old. RIDOT regularly examines roads to determine if they are cracking or showing signs of other minor deterioration. When treatment is deemed necessary, one of the first options is to put in a crack seal. If damage is more severe, crews apply an asphalt-rubber chip seal, which can be used on large resurfacing jobs in hot mixes or as sprayapplied membranes. Thin treatments that do not involve a lot of time or effort, such as crack seals, asphalt-rubber chip seals, slurry seals, and microsurfacing, are encouraged by the Federal Highway Administration.
Preventive maintenance techniques can extend pavement life by 5-6 years and make highway funding stretch further. In addition to saving money for materials, asphalt-rubber treatments save labor costs, because they do not take long to apply.

Supplemental Information:
Page Range: pp 15, 18

TRT Terms: Asphalt rubber; Chip seals; Cost effectiveness; Pavement cracking; Pavement maintenance; Pavement performance; Preservation; Preventive maintenance; Repairing; Resurfacing; Seal coating; Slurry seals; State departments of transportation

Geographical Terms:
Rhode Island

Identifier Terms: U.S. Federal Highway Administration
Subject Areas: I61 Equipment and maintenance methods; H40 MAINTENANCE, GENERAL
Availability:
- University Microfilms
  300 North Zeeb Road
  Ann Arbor, MI 48103 USA

TRIS Files: HRIS
Database: TRIS Online

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Date: Wednesday, August 30, 2006

Record **18** of **36** in **TRIS Online** for **kw:slurry kw:rubber**

Title: MICROSURFACING WITH NATURAL LATEX-MODIFIED ASPHALT EMULSION: A FIELD EVALUATION
Accession No: 00483629
Authors:

- Pederson, C M
- Schuller, W J
- Hixon, C D

Journal Title:

- Transportation Research Record No. 1171
  Publisher: Transportation Research Board
  ISSN: 0361-1981

Corp. Authors / Publisher:

- Transportation Research Board
  http://trb.org
  500 Fifth Street, NW
  Washington, DC 20001 USA

Publication Date: 19880000
Description: p. 108-112; Figures(4); References(2); Tables(5)
Abstract: This paper presents an evaluation of the use of emulsified asphalt in a relatively new process called microsurfacing. The process was developed in Germany and was first used in the United States in late 1980. Natural latex rubber is incorporated into the asphalt emulsion and mixed with aggregate and other additives in a traveling pug mill similar to but larger than that of a regular slurry seal machine. The test section that was selected for microsurfacing is 3 mi of four-lane divided highway in an urban area. Construction was completed in June 1983. The data indicate that the service life of the test section has been enhanced. It is recommended that microsurfacing be approved for routine use in restoring flexible pavements to fill surface ruts and cracks, seal the surface, and restore skid resistance.
Supplemental Information: This paper appears in Transportation Research Record No. 1171, Asphalt Materials and Mixtures.
TRT Terms: Emulsified asphalt; Field tests; Flexible pavements; Latex asphalt; Service life; Test sections
Other Terms: Microsurfacing; Restoration
Subject Areas: I31 Bituminous binders and materials; H31 BITUMINOUS MATERIALS AND MIXES
ISBN: 0-309-04710-2
Availability:

- Transportation Research Board Business Office
  500 Fifth Street, NW
  Washington, DC 20001 USA
  Order Document: http://nationalacademies.org/trb/publications/tris/out_of_print.html

TRIS Files: HRIS
Database: TRIS Online

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Date: Wednesday, August 30, 2006

Record **36** of **36** in **TRIS Online** for **kw:slurry kw:rubber**

Title: REFLECTION CRACKING N BITUMINOUS OVERLAYS
Accession No: 00210476
Corp. Authors / Publisher:

- Colorado Department of Highways
  4201 East Arkansas Avenue
  Denver, CO 80222 USA
  Department of Transportation
  400 7th Street, SW
  Washington, DC 20590 USA
- Federal Highway Administration
  http://www.fhwa.dot.gov
  400 7th Street, SW
  Washington, DC 20590 USA

Description: 48 p.

Abstract: NINE DIFFERENT TREATMENTS TO THE PAVEMENT WERE INCLUDED IN THE DESIGN OF AN INTERSTATE PROJECT IN COLORADO TO FIND A METHOD OF REDUCING OR ELIMINATING REFLECTION CRACKING THROUGH BITUMINOUS OVERLAYS. EACH TREATMENT IS REPRESENTED BY TWO 1,000-FOOT-LONG SECTIONS; TWO STANDARD SECTIONS WILL BE USED AS A BASIS FOR COMPARISONS. THE NONE TREATMENTS USED TO REDUCE REFLECTIVE CRACKING ARE: (1) ASPHALT REJUVENATING AGENT; (2) POLYPROPYLENE FABRIC; (3) ASPHALT EMULSION SLURRY; (4) SQUEEGEE SEAL; (5) HEATER BLADE SACRIFIER, (6) PLANT MIX SEAL; (7) HAND POURED CRACK FILLING; (8) RUBBERIZED ASPHALT CEMENT; AND (9) RUBBER EMULSION. PRE-AND-POST CONSTRUCTION EVALUATIONS AS WELL AS DESCRIPTION OF THE CONSTRUCTION METODS ARE INCLUDED. ON COMPLETION OF THIS STUDY, THE MOST FAVORABLE SYSTEM FOR REDUCING REFLECTIVE CRACKING CAN BE IMMEDIATELY IMPLEMENTABLE. /FHWA/

Supplemental Information:
STATE STUDY NO 1483

TRT Terms: Bituminous overlays; Reduction (Chemistry); Reflection cracking
Other Terms: Reduction
Subject Areas: H31 BITUMINOUS MATERIALS AND MIXES; H40 MAINTENANCE, GENERAL; H24 PAVEMENT DESIGN AND PERFORMANCE

Document Source:

- Federal Highway Administration
  http://www.fhwa.dot.gov
  400 7th Street, SW
  Washington, DC 20590 USA

TRIS Files: HRIS
Database: TRIS Online

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United States Patent **5,539,029**
Burris **July 23, 1996**

Asphalt emulsion-rubber paving composition

Abstract

A method of preparing an asphalt emulsion-rubber paving composition comprises combining an aqueous asphalt emulsion, water, latex rubber, minus 40 size rubber particles, and a thickening agent, mixing said materials at substantially ambient temperature to form a substantially homogeneous liquid composition, adding to said liquid composition between about 5 and about 15 pounds of aggregate per gallon of said gallon, and mixing the components at substantially ambient temperature to form such paving composition.

Inventors: **Burris; Michael V.** (Oceanside, CA)
Appl. No.: **08/389,623**
Filed: **February 21, 1995**

Current U.S. Class: **524/60** ; 521/41; 521/44.5; 521/45; 524/59; 524/71
Current International Class: C08L 95/00 (20060101)
Field of Search: 521/40,40.5,41,45,44.5 524/59,60,61,71

References Cited [Referenced By]

U.S. Patent Documents

2700655	January 1955	Endres
3284397	November 1966	Johnston
3891585	June 1975	McDonald
3900692	August 1975	Rostler

3919148	November 1975	Winters et al.
4018730	April 1977	McDonald
4021393	May 1977	McDonald
4041712	August 1977	Stepien, Jr. et al.
4069182	January 1978	McDonald
4137204	January 1979	McDonald
4193816	March 1980	Ferm et al.
4548962	October 1985	Lindmark
4564310	January 1986	Thelen et al.
4609696	September 1986	Wilkes
4621108	November 1986	Burris
5151456	September 1992	Elias
5180428	January 1993	Koleas

Foreign Patent Documents

0013603	Jan., 1991	JP

Primary Examiner: Szekely; Peter A.
Attorney, Agent or Firm: Seiler; Jerry R.

Parent Case Text

This application is a continuation of application Ser. No. 08/212,034, filed Mar. 11, 1994 now abandoned.

Claims

I claim:
1. A method of preparing an improved asphalt emulsion-rubber paving composition comprising:

preparing a liquid composition by combining an aqueous asphalt emulsion, water, a thickening agent, latex rubber, and rubber particles of a size passing through a 40 mesh U.S. series sieve, wherein the latex rubber:rubber particle ratio is between about 1:3 and 1:5, by weight, respectively, mixing said components at substantially ambient temperature to form a substantially homogeneous liquid composition, adding to said liquid composition between about 5 and about 15 pounds of aggregate per gallon of said

liquid composition, and mixing the components at substantially ambient temperature to form said paving composition.

2. A paving composition prepared by the method of claim 1 wherein the components of said liquid composition comprise:

about 15-25% water,

about 50-75% asphalt emulsion,

about 1-5% latex rubber,

about 3-15% rubber particles, wherein the latex rubber:rubber particle ratio is between about 1:3 and about 1:5, by weight, and

about 0.1-2% thickening agent, said amounts being by weight of the liquid composition.

3. A composition of claim 2 wherein said asphalt emulsion comprises between 55% and 75%, by weight of said liquid composition.

4. A composition of claim 2 further comprising between about 1% and about 8% clay, by weight of said liquid composition.

5. A composition of claim 2 further comprising between about 0.1 and 0.5% carbon black, by weight of said liquid composition.

6. The composition of claim 2 wherein the amount of aggregate in said paving composition is between about 5 and about 15 pounds per gallon of said liquid composition.

Description

BACKGROUND OF THE INVENTION

The use of rubber, especially rubber particles such as ground up rubber tires in paving compositions is desirable since the resulting pavements have improved skid resistance and flexibility. Heretofore, such paving compositions, including asphalt-rubber emulsions, have been prepared under hot-mix conditions requiring heating a paving grade asphalt with the particulate rubber. An example of such a method is disclosed in U.S. Pat. No. 4,018,730. However, heating of rubber, typically using old ground up rubber tires at the temperatures heretofore required for blending or mixing with the asphalt compositions, above 300.degree. F., and typically between about 350.degree.-500.degree. F., results in significant volatilization of the rubber components including elemental sulfur which forms highly toxic and undesirable hydrogen sulfide. Such hot-mix

processing is undesirable and unacceptable where environmental standards and air pollution controls restrict or prevent the use of such methods.

SUMMARY OF THE INVENTION

The improved asphalt emulsion-rubber paving compositions of the present invention are prepared by mixing together a liquid composition comprising an asphalt emulsion, rubber latex, rubber particles, thickening and/or thixotropic agents and water with aggregate. The liquid asphalt emulsion-rubber composition is produced without the use of heat at any stage of the processing or mixing to achieve a highly desirable emulsion paving composition. The method is carried out entirely at ambient conditions thereby minimizing volatilization of asphalt and rubber components.

DETAILED DESCRIPTION OF THE INVENTION

The paving composition of the present invention comprises an aqueous asphalt-rubber emulsion composition and aggregate. The liquid emulsion composition is first prepared, and thereafter mixed with the aggregate. The asphalt emulsion composition used in preparing the paving composition of the present invention is preferably an emulsion of a penetration grade asphalt having between about 50 and about 75% solids. The penetration grade asphalts have a penetration above about 10 and up to about 300 dmm at 77.degree. F. (25.degree. C.). Preferred asphalt emulsion compositions are of SS type and especially the SS-1h asphalt emulsions, known to those skilled in the art. Such emulsions comprise anionic emulsified asphalts having a viscosity SSF at 77.degree. F. (25.degree. C.) sec. of between about 20 and 100 (ASTM Test D88), with a distillation residue penetration at 77.degree. F. of between about 40 and about 90 dmm (ASTM tests D244 and D5). The preferred SS-1h anionic emulsions are prepared using petroleum sulfonates or sulfates, soap-type emulsifying agents, typically the alkyl metal salts of higher fatty acids including lauric, myristic, palmitic, oleic, ricinoleic, linoleic acids and the like, or mixtures of acids available from animal or vegetable oils. Other examples of anionic emulsifiers are described in my U.S. Pat. No. 4,282,037, the description of which is incorporated herein by reference. A preferred anionic emulsifier comprises a rosin acid soap particularly a Vinsol.RTM. resin soap. Alternatively, the asphalt emulsion may be a nonionic emulsifying compositions using emulsifiers including long chain polyoxyethylene or polyoxypropylene groups in fatty acid, alcohol, amide, or amine molecules. These emulsifiers do not ionize but acquire their hydrophilic characteristics from oxygenated side chains, i.e., polyoxyethylene or polyoxypropylene chains combined with the oil-soluble fatty acid, alcohol amine or amide component of the molecule. More specific descriptions of such emulsifiers are also disclosed in my aforesaid U.S. Pat. No. 4,282,037, incorporated herein by reference. The asphalt emulsion composition comprises a major amount of the liquid emulsion composition, preferably 55%-75%, by weight.

The rubber latex material comprises a rubber emulsion or latex in which small globules or particles of natural or synthetic rubber are suspended in water with emulsifying agents.

The preferred rubber is styrene-butadiene (SBR), neoprene, or natural rubber. SBR latexes normally have a major amount of rubber present. For example, a commercially available SBR material contains about 68-70% rubber and about 30% water. The SBR rubber may also be cross-linked, for example, with carboxylate groups resulting from treatment with methacrylic acid, or the like. Styrene-butadiene-styrene block copolymers sold under the registered trademarks Kraton.RTM. or Hytrel.RTM. may be used. Commercially available neoprene latexes have a solids content of about 35%, while a commercially available natural rubber latex has about 60% rubber. Other useful rubbers include acrylic, nitrite, butyl, polyurethanes and silicones, and block copolymers such as styrene-isoprene (SIS) and styrene-ethylene-vinyl acetate (SEVAS). In the latexes, a small amount of emulsifying agent is present which may be cationic, nonionic or anionic. In the preferred SBR latexes, a fatty acid soap is used while in natural rubber natural proteins serve as anionic emulsifiers and stabilizers. Commercially available neoprene latex normally uses nonionic emulsifiers. The amount of rubber latex used in the liquid emulsion is preferably between about 0.5% and about 5%, by weight.

A thickener or thixotropic agent is also used in the liquid emulsion composition to achieve the desired viscosity. Suitable thixotropic agents include polyacrylic resins, carboxyvinyl resins, polyethylene maleic anhydrides, polysaccharides, and the like. The amount of thixotropic agent added is required to adjust viscosity of the final composition to between about 4,000 and about 5,000 centipoise. The amount of thickener used is typically between about 0.2 and about 2%, by weight, of the liquid emulsion composition.

The rubber used in the composition of the invention comprises particulate rubber, especially ground up rubber tires having a particle size of minus 40, U.S. sieve series, i.e., which will pass through a 40 mesh U.S. series sieve. The amount of particulate rubber present in the liquid emulsion composition is that necessary to give a minimum of about 3%, by weight, in the residue. Accordingly, between about 7 and about 10%, weight, in the emulsion composition is preferred.

It may also be desirable to incorporate surface active clay in the liquid emulsion composition, useful as an emulsifying additive or stabilizer for the emulsion composition. Preferred clays comprise sodium bentonite or sodium montmorillonite. When used alone, the bentonite may be used in amounts of up to about 10%, preferably between about 1% and about 8%, by weight, of the liquid emulsion. Other clays having surface active properties may also be used, for example, hydrated aluminum silicate clays, kaolin, kaolinite, halloysite, and prophyllite and the hydrated magnesium silicate clays such as serpentine, chrysotile, and talc.

A small amount of coloring material such as carbon black or graphite fibers is preferably added to give a desirable dark, black color to the final composition. A typical additive of this type comprises a 50% aqueous solids dispersion of carbon black used in the amount of between about 0.10 and about 0.50%, by weight, of the liquid emulsion composition.

In adding and mixing the various components of the composition, a number of different combinations of materials and steps may be utilized within the purview of the invention. For example, water and clay may be mixed alone and allowed to stand for at least a few hours, typically overnight, and thereafter the asphalt emulsion and rubber particles added and mixed, or the aforesaid ingredients may be all combined and mixed together to form a substantially homogeneous liquid composition. However, the water, rubber particles, and clay are preferably first mixed together, with the subsequent addition and mixing of the asphalt emulsion and carbon black. Thereafter, the thickener is added to adjust the viscosity of the liquid emulsion. The latex rubber composition may be added at any convenient time, either with the first group of materials mixed, or later, when desired.

An important aspect of the liquid emulsion composition, prior to the mixture with aggregate, is the ratio of latex rubber:rubber particles. The presence of the rubber latex in the composition is to prevent separation of the rubber particles in the liquid mixture as well as in the final composition. Accordingly, in the preferred embodiment, the latex rubber:rubber particle ratio is between about 1:3 and about 1:5, by weight, respectively.

The components of the liquid emulsion composition are mixed in any suitable way in order to obtain the desired homogeneity, but preferably using a blender, such as a ribbon blender, or the like which gives sufficient agitation and yet full blending of the different components. The amount of water present in the liquid composition is minor, and preferably between about 10 and about 30%, by weight, and more preferably between about 15 and about 25%, by weight. However, the specific amount of water used can be adjusted to achieve the desired consistency, and preferably with the thickener used to give the preferred viscosity of between about 4,000 and about 15,000 cp, and with the aforesaid amount of asphalt emulsion present.

Following preparation of the aforesaid liquid emulsion composition, aggregate is added and thoroughly mixed to obtain the final paving composition material. The aggregate may be any suitable aggregate including crushed rock, recycled glass, sand, graded silica, and the like, commonly used for such applications. The particle size of the aggregate is preferably #16 minus, U.S. Series, (16 mesh) i.e., will pass through a 16 mesh sieve, although for certain applications, larger particles may be used. However, preferably, to obtain the desired consistency, the aggregate materials should be no larger than #8 mesh range. The amount of aggregate used in the final composition is preferably between about 5 and about 15 pounds aggregate per gallon of the liquid composition. The viscosity of the composition changes when aggregate is added. Suitable final paving composition viscosities are between about 8,000 to 30,000 cps depending on gradation of aggregate used.

By way of example, a paving composition was prepared as follows:

Water (19.45%), sodium bentonite clay (3.00%), SS-1h asphalt emulsion (60% solids) (68.00%), carbon black (0.30%) (50% solids dispersion), SBR latex (69% solids) (Ultrapave UP-70.RTM., Goodyear) (1.75%), ground up rubber tires (#40 minus particle

size) (7.00%), and sodium polyacrylate thickener (0.50%), 13% solids (Paragum 165.RTM.) were mixed at ambient temperature of about 65.degree. F.-75.degree. F. The materials were combined by first mixing the water and clay, allowing the mixture tostand overnight, thereafter adding the asphalt emulsion, latex and rubber tires together with the carbon black. The thickener was added to adjust the viscosity to between 4,000 and 5,000 cps. The resulting composition was mixed in a ribbon blender at about 68.degree. F. until it was substantially homogeneous and thereafter was further mixed at 65.degree.-70.degree. F. in the ribbon blender with #16 minus aggregate in a ratio of 8 pounds of aggregate per gallon of a liquid composition. The aggregate containing composition had a viscosity of about 8,000-10,000 cps. The resulting composition was placed on a road surface as a flex seal slurry on a chip seal, and tested by the California test method to a skid number of between 44 and 46.

* * * * *

Images
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Typed Drawing

Word Mark	**FLEX SEAL**
Goods and Services	IC 019. US 001 012 033 050. G & S: ASPHALT EMULSION COMPOSITION FOR SEALING PAVEMENT. FIRST USE: 19881109. FIRST USE IN COMMERCE: 19881109
Mark Drawing Code	(1) TYPED DRAWING
Design Search Code	
Serial Number	75574381
Filing Date	October 21, 1998
Current Filing Basis	1A
Original Filing Basis	1A
Published for Opposition	September 5, 2000
Registration Number	2407717
Registration Date	November 28, 2000
Owner	(REGISTRANT) Flex Products, Inc. CORPORATION NEVADA 5235 Avenida Encinas, Suite A Carlsbad CALIFORNIA 92008
Attorney of Record	Jerry R. Seiler

Disclaimer	NO CLAIM IS MADE TO THE EXCLUSIVE RIGHT TO USE "SEAL" APART FROM THE MARK AS SHOWN
Type of Mark	TRADEMARK
Register	PRINCIPAL
Live/Dead Indicator	LIVE

APPENDIX B

AGENCY- INDUSTRY SURVEYS

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CIWMB Evaluation of Rubberized Slurry Seal Materials
Questionnaire for Users (Owners and Agencies)

Background Information

Name of Agency

Person Completing Survey/Title

Telephone Number/Fax Number

Email Address

Do you currently use or plan to use slurry seals on your roadway system?

- Yes
- No
- Plan to use in the future If so, when?

Why?

2. If you currently use slurry seals, do you expect to continue to use them?

- Yes
- No
- Undecided

Why?

3. What type(s) of Slurry Seal materials do you use?

- ☐ Conventional Slurry Seal
- ☐ Rubberized Slurry Seal — If so, what type? _____
- ☐ Polymer Modified Slurry Seal — Details? _____
- ☐ Others — Please specify: _____

4. On what types of streets are slurry seals used in your jurisdiction?

- ☐ Residential
- ☐ Commercial Developments
- ☐ Other
- ☐ Arterial
- ☐ Public Parking Lots

5. Approximately how much (yd^2 or tonnage) of each type of slurry seal material have you used in each year from 2003 to present (2006)?

Year	Conventional SS	Rubberized SS	Polymer Modified SS	Others
2003				
2004				
2005				
2006				

6. Based on your experience, about how long do you expect each type of slurry seal to last?

Service Life (years)	Conventional SS	Rubberized SS	Polymer Modified SS	Others
Expected:				
Minimum				
Maximum				

Other Comments

7. Have you found any relationship between slurry seal service life and condition of the underlying pavement surface prior to application of the slurry seal?

Yes No

Comments

8. On a scale of 1 (poor) to 5 (excellent), please rate your agency's experience regarding typical performance of each type of slurry seal product.

	Conventional SS	Rubberized SS	Polymer Modified SS	Others
Performance Rating (1 to 5)				

Comments

9. Have you experienced any problems with the construction of slurry seals? If so, please describe.

Slurry Seal Type	Construction Problems (e.g. workmanship, equipment)
Conventional Slurry Seal:	
Rubberized Slurry Seal:	
Polymer Modified Slurry Seal:	
Others:	

10. Have you experienced any problems with the long term performance of slurry seals? If so, are these occasional or frequent? Limited or widespread? Please describe any specific problems.

Slurry Seal Type	Performance Problems (e.g. abrasion, delamination, cracking)
Conventional Slurry Seal:	
Rubberized Slurry Seal:	
Polymer Modified Slurry Seal:	
Others:	

11. Does your agency require submittal and approval of slurry seal mix designs prior to their use?

- Yes — If yes, can you provide MACTEC with copies of typical slurry seal mix designs? (Note: We are interested in designs that have performed well and any that performed poorly)
- No — If no, is any mix design information included in the respective project files?

Comments

12. Do you perform any Quality Assurance or acceptance testing of slurry seal materials and/or construction for evaluation of compliance with specifications?

- Yes — If yes, please list the tests used and describe any other evaluation criteria
- No — If no, what are the criteria for acceptance and payment?

Comments

13. Please identify companies/contractors that have provided and/or placed slurry seal materials for your Agency.

	Companies			
Conventional Slurry Seal:				
Rubberized Slurry Seal:				
Polymer Modified Slurry Seal:				
Others:				

14. Please list typical Unit Costs ($/yd^2) that your agency paid for the respective types of Slurry Seal products.

Year	Conventional SS	Rubberized SS	Polymer Modified SS	Others
2004				
2005				
2006				

15. What type(s) of maintenance activities does your jurisdiction apply to pavements with slurry seals? Does the effectiveness of maintenance treatments differ among the different slurry seal types?

- ☐ None
- ☐ Crack Sealing
- ☐ Patching
- ☐ Other

Comments

Other Comments:

Submit Survey

Reset

Thank you for your participation!

CIWMB Evaluation of Rubberized Slurry Seal Materials
Questionnaire for Contractors and Producers

Background Information

Name of Company:

Person Completing Survey:

Telephone Number:

Email Address:

1. What type of Slurry Seal do you produce?

- ☐ Conventional Slurry Seal
- ☐ Rubberized Slurry Seal
- ☐ Polymer Modified Slurry Seal
- ☐ Others - Please specify:

2. Please indicate who performs the design of your slurry seals?

- ☐ Private testing laboratory
- ☐ Emulsion supplier
- ☐ Others - Please specify:

3. Which mix design procedure, type of binder composition, aggregate size, and application rates are typically used?

Conventional Slurry Seal:

Mix Design:

Binder Composition:

Aggregate Size:

Application Rates:

Rubberized Slurry Seal:

Mix Design:

Binder Composition:

Aggregate Size:

Application Rates:

Polymer Modified Slurry Seal:

Mix Design:

Binder Composition:

Aggregate Size:

Application Rates:

Others:

Mix Design:

Binder Composition:

Aggregate Size:

Application Rates:

4. What QC testing and evaluation do you perform on these systems? Please identify.

- ☐ Binder Testing:
- ☐ Aggregate Testing:
- ☐ Field QC Tests:

5. How much of each (approximately) have you produced (yd^2) in the years noted below (please specify the location)?

Year	Conventional SS	Rubberized SS	Polymer Modified SS	Others
2003				
2004				
2005				
2006				

6. What advantages does your product provide compared with other product in the market?

Slurry Seal Type	Advantages

Conventional Slurry Seal:

Rubberized Slurry Seal:

Polymer Modified Slurry Seal:

Others:

7. Is there some placing or environmental limitation for your product?

Slurry Seal Type	**Limitations**
Conventional Slurry Seal:	
Rubberized Slurry Seal:	
Polymer Modified Slurry Seal:	
Others:	

8. What is your experience regarding the service life of slurry seals (how long do you expect them to last)?

Service Life (years)	Conventional SS	Rubberized SS	Polymer Modified SS	Others
Expected Life:				
Minimum:				
Maximum:				

Other Comments:

9. What type(s) of maintenance activities do you recommend to be applied to pavements treated with your product?

- None
- Crack Sealing
- Patching
- Other:

Comments:

10. Have you found any relationship between slurry seal service life and condition of the underlying pavement surface prior to application of the slurry seal?

- Yes
- No

Comments:

11. Please provide with some typical Unit Costs ($/yd^2) for Slurry Seals?

Year	Conventional SS	Rubberized SS	Polymer Modified SS	Others
2004				
2005				
2006				

12. Other Comments:

Submit Survey | Reset

Thank you for your participation!

APPENDIX C

SURVEYS SUMMARIES

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Responses to Questions for Cities and Counties Survey

1. Do you currently use or plan to use slurry seals on your roadway system?		
Yes	Rubberized slurry has an effective, pleasant asthetic appearance, a long lifespan and it provides effectiveness as an oil additive treatment to our asphalt streets. It extends the flexible lifespan and sealing of our asphalt streets so overlays can be be dalayed by 7 to 10 years if applied on a programmed basis of every 5 to 7 years. Slurry is a relatively inexpensive preventative maintenance program, which also improves the visual appearance of residential streets. Effective preventative maintenance product. Useful tool for preventive maintenance. To provide a smoother riding surface, seal the cracks, make the street darker. Cost-effective, preventative maintenance strategy to prolong the life of the road surface. We find it a valuable preventative maintenance process. It is a good product that helps to maintain our extensive roadway system. To extend the life of the pavement. It extends the useful life of these low traffic impacted streets at a substantially lower cost than overlay. In order to maintain streets resurfaced/paved within the last ten years or so before they start to lose the fine (top) materials. It's an excellent program that extends the pavement's life. Cost effective for minimum budget. To extend pavement life. Slurry sealing is done in order to extend the life of our city streets. Pavement is in good condition, only issue is exposed and dry aggregate needs oil and fine in the pavement	26
No	Hasn't held too well in our city due to the High truck traffic (i.e.: high TI's). We have used them in the past on some of our local streets with low ADT's.	1
Future	July 2007; 2011	2

2. If you currently use slurry seals, do you expect to continue to use them?		
Yes		26
No		1
Undecided	The City used to have a slurry seal program in the past years until 2000, but due to pavement aging, where it was unreasonable to just place a thin slurry coat, the City concentrated on resurfacing streets instead.	1
N/A		1

3. What type(s) of Slurry Seal materials do you use?		
Conventional		15
Rubberized		17
Polymer Modified		3
Other	Slurry Seal with Latex	1

4. On what types of streets are slurry seals used in your jurisdiction?		
Residential		27
Arterial		11
Commercial		2
Public Parking		12
Other		0

5. Approximately how much (yd^2 or tonnage) of each type of slurry seal material have you used in each year from 2003 to present (2006)?		
Conventional 2003	1,650; 890,000; 5,000; 72,000; 220,000; 1,500; 920	7
Conventional 2004	1,800; 25,000; 5,000; 1,500; 240,238; 1,100	6
Conventional 2005	1,700; 120,000; 5,000; 61,020; 14,406; 222,000; 128,823; 44,800	8
Conventional 2006	2,300; 100,000; 5,000; 109,000; 1,000; 129,987; 246,400; 44,800	8
Rubberized 2003	8,500; 77,800; 120,000; 800,000; 64,300; 32,100; 17,600; 277,800; 1,818,667; 84,500	10
Rubberized 2004	8,700; 83,300; 544,000; 650,000; 42,400; 277,778; 277,800; 5,456,000; 84,900	9
Rubberized 2005	8,000; 88,900; 718,300; 600,000; 42,400; 277,800; 5,456,000; 47,500	8
Rubberized 2006	92,200; 609,800; 700,000; 37,300; 72,800; 388,900; 5,456,000; 59,100	8
Polymer Modif 2003	3,700	1
Polymer Modif 2004	3,600	1
Polymer Modif 2005	3,300	1
Polymer Modif 2006	4000; 5,000; 367,000	3
Other 2005	161,685	1

Responses to Questions for Cities and Counties Survey

6. Based on your experience, about how long do you expect each type of slurry seal to last?		
Conventional Expected	3; 7; 7; 7; 7; 6; 5; 5; 5; 3; 3; 7; 2; 2; 7; 5; 7; 6; 7; 5; 7; 7	22
Conventional Minimum	1; 7; 5; 5; 3; 5; 4; 4; 2; 2; 6; 1; 1; 5; 3; 5; 5; 4; 4; 3	20
Conventional Maximum	3; 10; 10; 10; 5; 7; 6; 7; 4; 5; 8; 3; 3; 10; 7; 10; 9; 6; 7; 10	20
Rubbberized Expected	7; 7; 8; 7; 7; 5; 4; 7; 7; 7; 7; 5; 5; 7; 7; 10	16
Rubberized Minimum	5; 5; 6; 5; 6; 5; 2; 5; 5; 6; 3; 3; 5; 5; 7	15
Rubberized Maximum	9; 8; 10; 10; 8; 7; 5; 10; 8; 9; 7; 7; 9; 8; 15	15
PM Expected	7; 7; 4; 8; 10	5
PM Minimum	6; 3; 3; 6; 7	5
PM Maximum	12; 5; 6; 10; 15	5

7. Have you found any relationship between slurry seal service life and condition of the underlying pavement surface prior to application of the slurry seal?		
Yes	It always maximizes the life of Slurry Seal if it is applied to streets with minimul to no cracking. This definetly applies to conventional slurry. Rubberized tends to flex enough to keep small cracks from reflecting through if street is not crack sealed prior to slurry sealing. Severely cracked pavement reduces service considerably, through ground water infultration and reflective cracking Slurry seals wear quicker on street that have less ravelling If the street is "alligatered" (heavy cracking), the slurry seal will not last long, if the street is not heavily cracked up, the slurry seal will last much longer Cracks reflect through even after crack filled When the underlay is in sever cracking condition, the slurry seal life is shorter than expected We generally try to place the slurry seal on pavement before the pavement has deteriorated. There is some good slurry product available now that can actually extend the service life of poor underlying pavement. If roads are around 5 years old the slurry seams to bond better. We use slurry only on the streets rated 60 or up. If the surface pavement is in good condition the slurry seal last the expected life span Proper crack sealing and pothole repairing are absolutely crucial to achieve the expected slurry seal servic The slurry seal is only as good as the condition of the underlying pavement surface. Timing is essential in t Defintely the condition of the underlying pavement has an effect on the slurry seal service life. Exposed aggregate decreases life of slurry seal but is typically a major criteria in streets to receive slurry se Poor underlying surface will cause premature failure of slurry. Pavement last longer and there is less alligation Only the streets that are in "fair to good" condition per the Pavement Management System (PMS) rating sh Street must have a good subgrade and well maintained.	22
No	Not enough experience with the product.	7

8. On a scale of 1 (poor) to 5 (excellent), please rate your agency's experience regarding typical performance of each type of slurry seal product.		
Conventional	1.5; 5; 1; 3; 2; 4; 2; 3.5; 3; 2; 2; 3; 4; 2; 3; 4; 4; 4; 4; 4; 5	21
Rubberized	4.5; 5; 4; 3; 4; 4; 3.5; 3; 5; 5; 4.5; 4; 5; 3; 1; 3; 5; 4; 1; 4; 5	21
Polymer Modified	2; 5; 2; 3; 1; 1; 5	7
Other	1	1

Responses to Questions for Cities and Counties Survey

9. Have you experienced any problems with the construction of slurry seals? If so, please describe.		
Conventional	Old equipment, break downs, sloppy edges and overlaps, lack of oil content. Gutter lip build up. Trying to keep oil content in specification, lack of color consistency of material in the same area. Big issue for residents on neighborhood streets, raveling of rock in material. Varies with each contractor. In general, the slurry shows seams more and has some variation in shade between passes. Workmanship. Workmanship specifically at the lip of gutter areas Equipment, main concern is nozels distribution rate. More ravaling than reas and doesn't stay black as long as reas. Should crack seal pavement 6-12 months prior to application of any slurry seal. Equipment failures are common, workmanship hasn't been a problem for about 7 years. It takes a lot of oversight to ensure contractor compliance with specifications. Opening the street for traffic too soon after application of SS. Slurry seal applies best in summer months. Cold weather presents problems. The main problem that we encountered during construction was keeping vehicles off of the slurry seal while it was curing. Also, we placed slurry seals on areas that received heavy truck traffic, and we found that the Rutting of finished surface on hot days. Problems arise mostly during public notification of street closure and having constractor repost. No matter what we do after slurry application skuffing, skid marks are problems.	16
Rubberized	Some heavy overlaps, cleanup off concrete difficult, leaves marks. No major problems. Some minor problems with drying times. Poor workmanship with one particular Contractor. Cold weather sensitive. Workmanship, specifically at the lip of gutter areas Equipment, main concern is nozels distribution rate. Minor peeling immediately after placement which could have been from hydraulic fluid on the pavement. It takes a lot of oversight to ensure contractor compliance with specifications. Weather at the time of application is a very important factor in life of the product. Improper mix by operators and insufficient thickness of application. Power steering marks are prevalent. Some contractors' workmanship is not as good as others and their equipment may not be in good condition In our City we try to have a good control on the quality of the material by having it tested prior to application through an independent geotechnical consultant.	9
Polymer Modified		0
Other		0

10. Have you experienced any problems with the long term performance of slurry seals? If so, are these occasional or frequent? Limited or widespread? Please describe any specific problems.		
Conventional	General wear and tear of slurry surface over short period of time.Delamination on certain streets, frequent.Cracks reflecting through, frequent. Fading in color rapidly. Varies with contractor. Most problems are associated with abrasion from tires, poor seams or ravelling of loose aggregate. Underlying cracking comes back very quickly (less than a year). Widespread raveling and premature oxidation. Cracking and weathering. Some areas seem to have worn off quiker than others Cracks are reflecting thru. We seen both side of the spectrum. When we first started chatter was a common problem. Slurry seals were not intended to be a crack seal, there is already a method for that repair. Does not do well in the High Desert area and bleeds too much. Occasional abrasion problem. Fading.	11
Rubberized	Very minor incidents of delamination. Very limited. Raveling within cul-de sac bulbs and knuckles. Raveling of Type III REAS within turning movements (intersections and curvelinear streets). Delamination where excessive water runoff is present. Wrinkle effects at the intersections Does fairly well on residential streets but not on high traffic impact areas. Cracking problems that we have experinced in Buena Park are occasional and on limited areas near parkways and medians due to irrigation.	
Polymer Modified	Widespread raveling and premature oxidation.	1
Other		0

Responses to Questions for Cities and Counties Survey

11. Does your agency require submittal and approval of slurry seal mix designs prior to their use?		
Yes	Our only conventional slurry project had a mix degign performed by local lab. REAS design provided by contractor, must comply with GreenBook. Specifications per the Greenbook. Tyical mix design involves calibration of equipment by means of mixing and installing slurry seal on a section of roadway and sampling product for laboratory testing. The City adopted standads is the standard specifications (Green Book) Section 600-3. Type II from Green Book. Contractors are required to provide proof of quantities consistent with APWA specifications. Greenbook for typical mix design Per Greenbook. Per SSPWC.	20
No	We provide the mix design. We use a in-house crew. Calibration is a frequent task to ensure quality.	8
N/A		1

12. Do you perform any Quality Assurance or acceptance testing of slurry seal materials and/or construction for evaluation of compliance with specifications?		
Yes	WTAT, Consistency, Extraction, Water Content, Aggregate Gradation and Sieve Analysis. Greenbook testing criteria. Lab test. Wet track abrasion, oil and water content of emulsion, gradation of aggregate. Wet track abrasion, viscosity and others. We use a in-house crew. Calibration is a frequent task to ensure quality and skid abbrasion. City performs daily QA testing on REAS and emulsion samples collected. Wet Track Abrasion, Sieve Analysis, Bitumen and Rubber content analysis, water content analysis, density analysis, emulsion and aggregate mix ratio analysis. ASTM D3910, D2172. Extraction & Wet track abrasion test. Greenbood specifications. Sampling of aggregate and asphalt emulsion; gradation and sand equivalent tests and compared to specifications; samples of slurry seal will be taken directly from the slurry units and consistency and residual asphalt content tests are compared to specs; engineer may use the recorders and measuring facilities of the slurry seal unit to determine application rates, asphalt emulsion content, mineral filler and additive content. Gradation % passing, % moisture test, % add H20 test, % Emulsion test,% Residual RPME test, Wet Track We request contractor to do inspection test for 5000 square foot of the pavement to see the color and qual Material testing.	16
No	Pay by the gallon for REAS slurry oil off load tickets, including weight. Same for aggregate. Placement within specifications with inspection. All failures subject to warranty period (1yr.) Visual observation. Payment is based on weight of materials placed (weighmaster's certificates/tickets are required). Oil is paid separately from aggregate materials. Tickets are collected at the end of each working day form the Contractor. We have inspectors monitoring our projects. We used to do testing but stopped due to the turn around time of the tests performed. Tickets from the plant and the trucks. Visual by inspectors.	9
N/A		4

Responses to Questions for Cities and Counties Survey

13. Please identify companies/contractors that have provided and/or placed slurry seal materials for your Agency.		
Conventional	Roy Allen, CPM, Cal. Pavement Maint, Doug Martin Wheeler Paving, Doug Martin, Pavement Coatings Co Graham Pavement Coatings, Roy Allan, Doug Martin, Mission Paving Roy Allen Slurry Seal, All American Asphalt Am. Asph. South Roy Allan, All American South, Doug Martin, Pavement Coatings CPM S-2 Sealing CPM Excel Paving, Sequel Contractors Sully Miller Contracting Roy Allan Slurry Seal, Pavement Coatings Co., Doug Martin Contracting Co. Roy Allen, Valley Slurry Seal, PCN Slurry Pavement coatings, Roy Allen SS Sudhakar, Wheeler Paving, Roy Allen All American Asphalt Western Oil Spreading Services, Roy Allan, Concrete Pavement Management Sudhakar Company, Inc, Pavement Coatings Co, Roy Allen Doug Marting, Pavement Coatings, Roy Allen	20
Rubberized	American A.C. South, Pavement Coatings, Bond Blacktop American Asphalt South American Asphalt South, All American Asphalt, Petrochem Manufacturing American Asphalt South, Pavement Coatings American Asphalt South American Asphalt South, Bond Blacktop Petrochem American Asphalt American Asphalt South, Inc., Pavement Coatings, Inc. American Asphalt South, California Pavement Maintenance Company, Inc. American Asphalt So., All American Asphalt, Sutecar PMI American Asphalt South, Inc., All American Asphalt, Inc. American Asphalt South, All American Asphalt, Manhole Adjusting, CPM Manhole Adjusters, All American	15
Polymer Modified	Roy Allan, All American South CPM Bond Blacktop, Inc	3
Other		0

14. Please list typical Unit Costs ($/yd²) that your agency paid for the respective types of Slurry Seal products.		
Conventional 2004	0.5; 0.63; 3; 0.045; 0.89; 0.45; 0.78	7
Conventional 2005	0.5; 0.54; 1.8; 0.055; 0.1; 0.2; 0.99	7
Conventional 2006	0.65; 1.8; 0.06; 1.12; 0.81; 1.05	6
Rubberized 2004	3.95; 1.35; 1.58; 0.9; 0.94; 0.99; 3.4; 0.94	8
Rubberized 2005	4.27; 1.40; 1.05; 1.67; 0.93; 1.01; 0.95; 1.08; 1.17; 3.48; 1.07	11
Rubberized 2006	5; 1.53; 1.45; 1.78; 1.41; 1.44; 1.41; 1.17; 5.76; 1.29	10
Polymer Modif 2004	0.62	1
Polymer Modif 2005	0.65	1
Polymer Modif 2006	0.98; 1.67	2

15. What type(s) of maintenance activities does your jurisdiction apply to pavements with slurry seals? Does the effectiveness of maintenance treatments differ among the different slurry seal types?		
None		2
Patching		18
Crack Sealing		24
Other	Epoxy patching R&R - a.c. Localized removal	3

Responses to Questions for the Industry Survey

1. What type of Slurry Seal do you produce?		
Conventional		4
Rubberized		4
Polymer Modified		4
Other	We produce the rubberized emulsion as well as the slurry. Rubber Polymer Modified Slurry Micro-surfacing Tire Rubber Modified Slurry Seal Cationic	4

2. Please indicate who performs the design of your slurry seals?		
Private testing lab		3
Emulsion supplier		3
Other	We do in-house mix designs, also. Own lab. Thorworks	3

3. Which mix design procedure, type of binder composition, aggregate size, and application rates are typically used?		
Conventional Mix Design	I.S.S.A. I.S.S.A. ASTM-D 3910	3
Conventional Binder Composition	CQS-h CQS-1h CQS-1H	3
Conventional Aggregate Size	Type II Type I or Type II 3/8 (inch)	3
Conventional Application rates	12 Lbs/Sq yd 10-18 Lbs/Sq yd 8-20 Lbs/Sq yd	3
Rubberized Mix Design	Per ISSA/Greenbook Designed in home Green Book	3
Rubberized Binder Composition	RPME - Rubberized Polymer Modified Emulsion Modif CQS1-h RPME - Rubberized Polymer Modified Emulsion	3
Rubberized Aggregate Size	Fine Aggregate(per Greenbook), and Types I-III (per ISSA) Type I or Type II Mostly Type I	3
Rubberized Application rates	Depends on Aggregate Type 9-12 Lbs/Sq yd 25-30 sq. ft./gal	3
PM Mix Design	I.S.S.A. I.S.S.A. ASTM-D 3910	3
PM Binder Composition	PMCQS1-h LMCQS-1h CQS1H-1 to 4% latex	3
PM Aggregate Size	Types I, II and III Type I or Type II 3/8 (inch)	3
PM Application rates	9-25 Lbs/sq yd 10-18 Lbs./sq yd 8-20 Lbs/sq yd	3
Other Mix Design	In house design I.S.S.A. ASTM-D 3910	3
Other Binder Composition	Rubber modif CQS1-h M.S.E. CQS1H modified	3
Other Aggregate Size	Type I or II Type II or Type III 3/8 (inch)	3
Other Application rates	9-14 Lbs/ sq yd 15-30 Lbs/Sq Yd 8-20 Lbs/Sq yd	3

Responses to Questions for the Industry Survey

4. What QC testing and evaluation do you perform on these systems? Please identify		
Binder testing	Per Greenbook/ASTM Residual, softening point ASTM D 244	3
Aggregate testing	Per Greenbook/ASTM Sieve analysis, compatibility ASTM 203-5.2 (B)	3
Field QC tests	WTAT Wet Track Abraision Wet Track abrasion/table 302-4.3.3(A)	3

5. How much of each (approximately) have you produced (yd2) in the years noted below (please specify the location)?		
Conventional 2003	millions; 5,250,000	2
Conventional 2004	millions; 6,000,000; 932,550	3
Conventional 2005	millions; 6,750,000; 1,019,458	3
Conventional 2006	millions; 4,000,000; 593,000	3
Rubberized 2003	500,000; 111,000	2
Rubberized 2004	500,000; 250,000	2
Rubberized 2005	14,600,000; small amount; 400,000	3
Rubberized 2006	1,000,000	1
Polymer Modif 2003	millions; 2,500,000	2
Polymer Modif 2004	millions; 3,525,000; 2,797,650	3
Polymer Modif 2005	millions; 3,500,000; 3,058,374	3
Polymer Modif 2006	millions; 6,500,000; 1,779,000	3
Other 2003	150,000	1
Other 2004	varies	1
Other 2005	varies; 100,000	2
Other 2006	prototype work; 225,000	2

6. What advantages does your product provide compared with other product in the market?		
Conventional	Low costs, good performance. Inexpensive form of pavement maintenance, quick completion times, and lack of loose cover aggregate. Superior skid resistance, extended paving llife up to 7 years on the average, more aggregate per square yard, extends life of exsiting pavement by protecting from oxidation and deterioration, more pounds of material per dollars spent. Lower life-cycle cost. Higher product Stability from movement.	3
Rubberized	REAS provides a more predictable, durable, and longer lasting pavement treatment than most conventional slurries. REAS's black color is more uniform, and remains dark much longer than other slurries. Raveling is tremendously reduced, as is power steernig scuffing, compared to traditional slurries. And, its' use of crumb rubber helps divert waste tires from the landfill. Gets rid of tire rubber, stays blacker longer. Inexpensive form of pavement maintenance, moderate completion times, excellent striping contrast, enviromentally conscience.	3
Polymer Modified	Extended wear, more resistant to rock loss, tearing and shoving. Inexpensive form of pavement maintenance, quick completion times, more durable then conventional systems, withstand higher pavement temperatures. Same as conventional slurry seal except that Polmer Modified slurry seal protects against water intrusion, fewer effects of aging, higher fixablity and better protection against power steering marks. Few cents higher that Conventional slurry but considerably less than Rubberized.	3
Other	Rubber Polymer Modified Slurry: When used with an engineered GTR (Ground Tire Rubber) composite, greatly improves the performance and wearability and allows more flexibility at lower temperatures with greater stability at high temperatures. Micro-Surfacing: Rut filling capabilitities, night time work, use a great depths without deformation, extremely quick completion times. Tire Rubber Modified Slurry Seal Cationic: In testing stage.	3

Responses to Questions for the Industry Survey

7. Is there some placing or environmental limitation for your product?		
Conventional	55 degrees and rising, no rain. Weather, traffic loads, pavement deformation. No.	3
Rubberized	REAS relies on an evaporative process to cure; weather variables such as temperature, wind, shade and humidity effect the drying time. REAS may not be used to fill ruts. It is not a quick-traffic or nightime application type product. REAS should not be placed when there is any likelyhood of rain. Needs warmer temperatures and/or no shade. Current REASS products are mostly slow setting. Weather, pavement deformation. No.	4
Polymer Modified	55 degrees and rising, no rain. Weather (but not as bad as previous two) traffic loads, pavement deformation. No.	3
Other	55 degrees and rising, no rain. No.	2

8. What is your experience regarding the service life of slurry seals (how long do you expect them to last)?		
Conventional Expected	6; 6.5; 8.5	3
Conventional Minimum	5; 5; 5	3
Conventional Maximum	7; 8; 15	3
Rubbberized Expected	7; 4; 6.5	3
Rubberized Minimum	5; 3; 5	3
Rubberized Maximum	10; 5; 8	3
PM Expected	7; 8.5; 8.5	3
PM Minimum	6; 7; 5	3
PM Maximum	8; 10; 15	3
Other Expected	7; 9.5; 8.5	3
Other Minimum	6; 7; 5	3
Other Maximum	8; 12; 15	3

9. What type(s) of maintenance activities do you recommend to be applied to pavements treated with your product?		
None		0
Patching		4
Crack Sealing		4
Other	Vegetation Control.	1

10. Have you found any relationship between slurry seal service life and condition of the underlying pavement surface prior to application of the slurry seal?		
Yes	Slurry should be used to replace lost fines, and to protect and preserve the integrity of generally sound pavement. It can sometimes been used effectively as a "bandaid" on pavement in need of immediate reconstruction but where funds are not available to do the required work. In this case needs to be understood that use of slurry it is a tempory fix only, and will not get a normal service life. I have seen roads in good condition get 18 years from a Type I slurry, I have seen roads in poor condition get 2 years from a Type II slurry. Slurry protects the roadway but it does not correct existing or underlying problems. Product will not extend the life of failed asphalt. All Slurry seal needs a stable foundation for maximum protection, performance, and life.	4
No		0

11. Please provide with some typical Unit Costs ($/yd2) for Slurry Seals?		
Conventional 2004	0.54; 0.54; 0.63	3
Conventional 2005	0.6; 0.9; 0.72	3
Conventional 2006	0.8; 0.99; 0.9	3
Rubberized 2004	0.95; 0.9	2
Rubberized 2005	1.1; 1.17	2
Rubberized 2006	1.36; 1.35	2
Polymer Modif 2004	0.6; 0.67; 0.72	3
Polymer Modif 2005	0.67; 1.06; 0.9	3
Polymer Modif 2006	0.88; 1.2; 1.35	3
Other 2004	2	1
Other 2005	2.25	1
Other 2006	1.1; 2.75	2

APPENDIX D

PHASE III "FAST TRACK" APPROACH PAVEMENT EVALUATION PHOTOGRAPHS

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City of Chula Vista

Calle La Mirada

Construction Date: August, 1964
REAS Treatment applied: March, 2004
Pavement Service Life: 43 years
Treatment Service Life: 3 years

City of Chula Vista

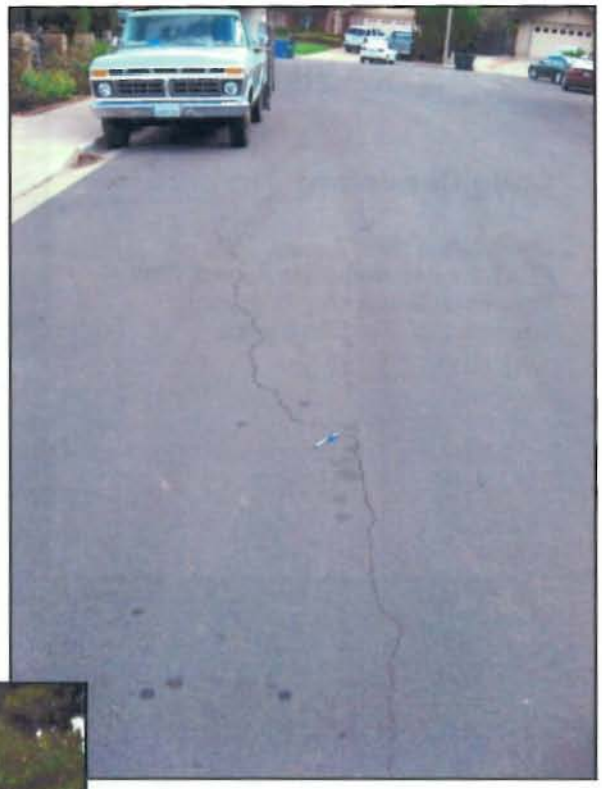
Huerto Place

Construction Date: August, 1995
REAS Treatment applied: March, 2004
Pavement Service Life: 12 years
Treatment Service Life: 3 years

City of Chula Vista

Wrangler Court

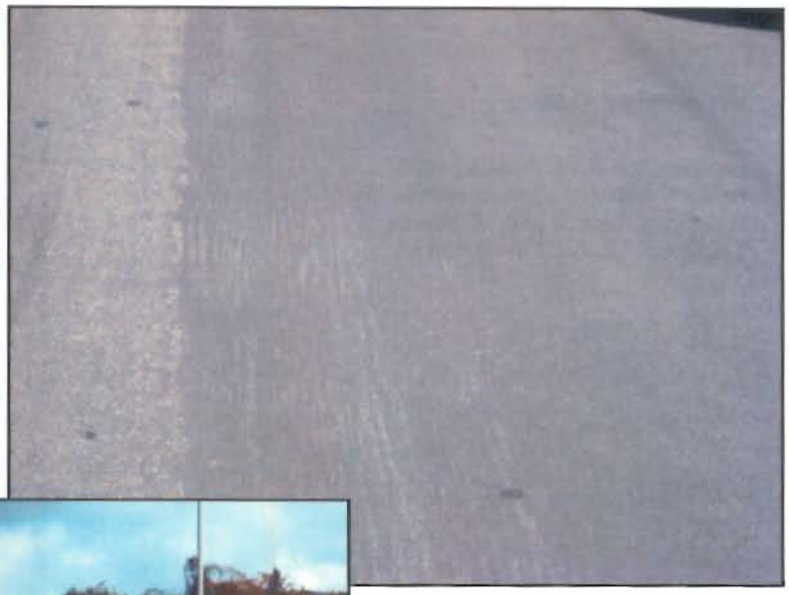
Construction Date: August, 1974
REAS Treatment applied: March, 2004
Pavement Service Life: 33 years
Treatment Service Life: 3 years



City of Chula Vista

Calle Candelaro

Construction Date: August, 1974
REAS Treatment applied: August, 2002
Pavement Service Life: 33 years
Treatment Service Life: 5 years



City of Chula Vista

Diamond Court (Section 1010)

Construction Date: August, 1989
REAS Treatment applied: August, 2002
Pavement Service Life: 18 years
Treatment Service Life: 5 years

City of Chula Vista

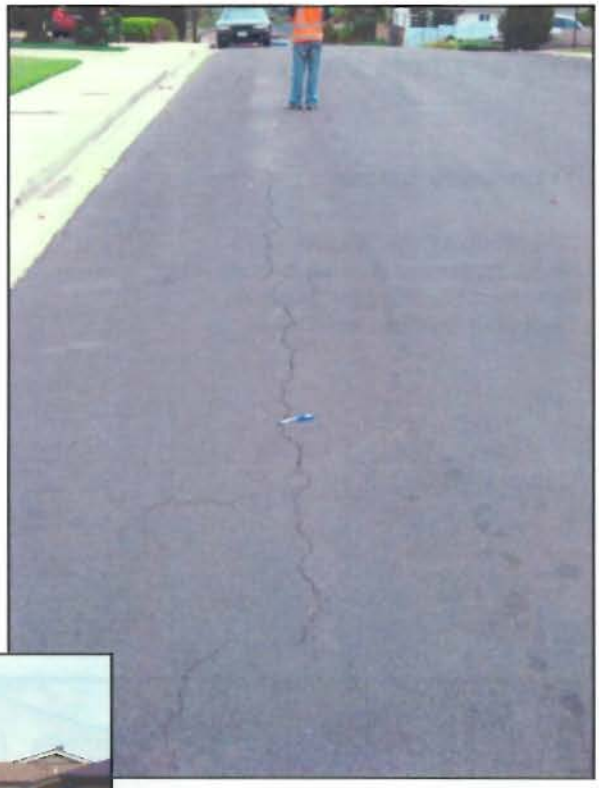
East Whitney Street

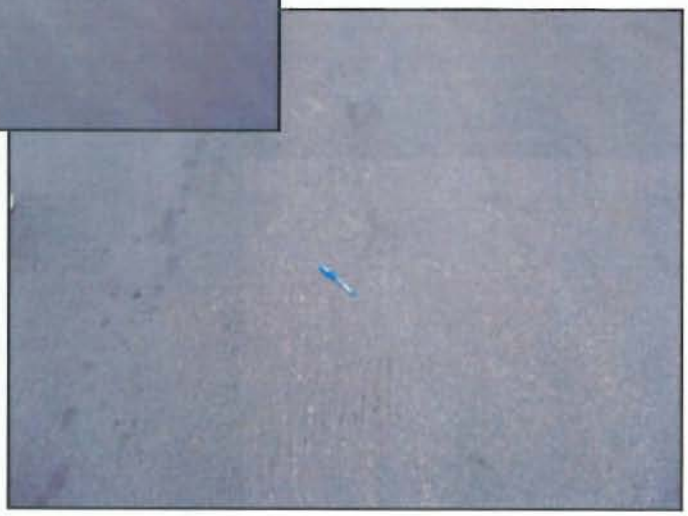
Construction Date: August, 1950
REAS Treatment applied: August, 2002
Pavement Service Life: 57 years
Treatment Service Life: 5 years

City of Chula Vista

Mission Court

Construction Date: August, 1964
REAS Treatment applied: August, 2002
Pavement Service Life: 43 years
Treatment Service Life: 5 years





City of Chula Vista

Tranquilo Lane

Construction Date: August, 1976
REAS Treatment applied: August, 2002
Pavement Service Life: 31 years
Treatment Service Life: 5 years

City of Chula Vista

Bristol Court

Construction Date: August, 1983
REAS Treatment applied: August, 2000
Pavement Service Life: 24 years
Treatment Service Life: 7 years

City of Chula Vista

Cedarbend Way

Construction Date: August, 1983
REAS Treatment applied: August, 2000
Pavement Service Life: 24 years
Treatment Service Life: 7 years

City of Chula Vista

Coltridge Lane

Construction Date: August, 1987
REAS Treatment applied: August, 2000
Pavement Service Life: 20 years
Treatment Service Life: 7 years

City of Chula Vista

Darthmouth Street

Construction Date: August, 1969
REAS Treatment applied: August, 2000
Pavement Service Life: 38 years
Treatment Service Life: 7 years

Sacramento County

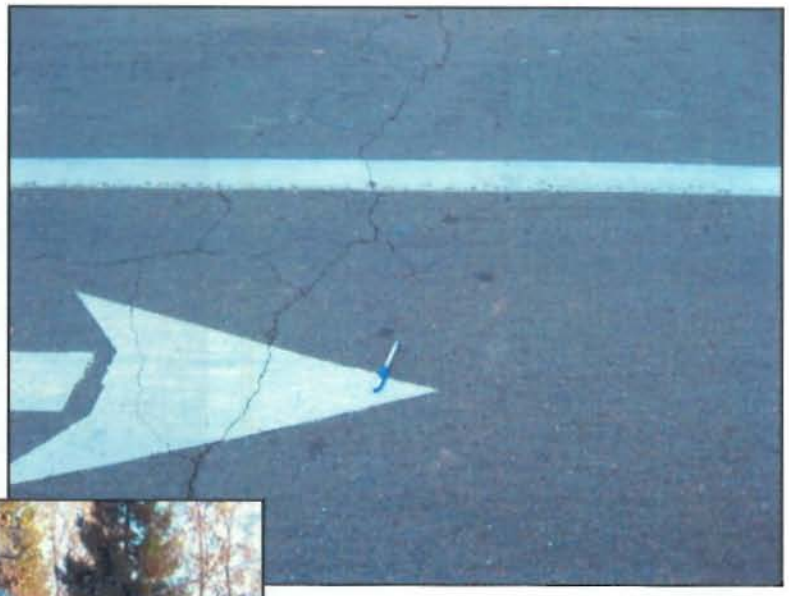
Blue Oak Drive

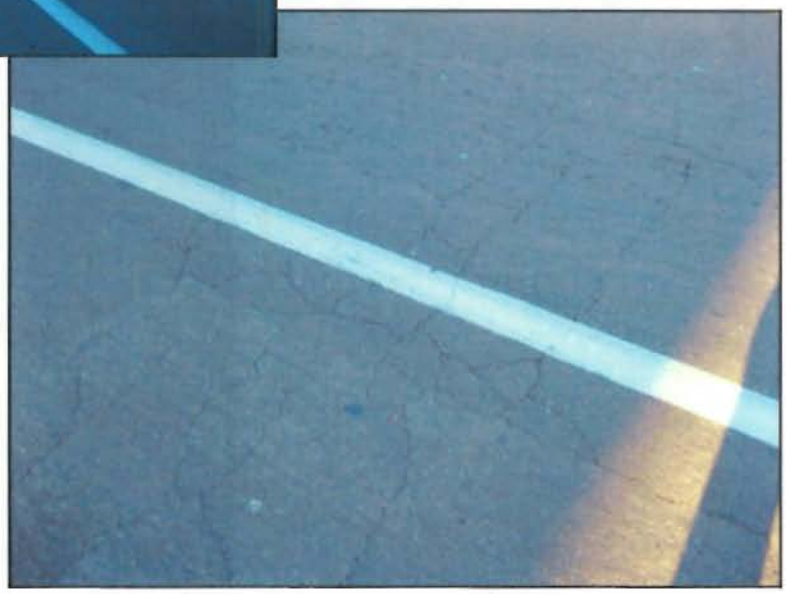
Construction Date: 1975
REAS Treatment applied: May 2002
Pavement Service Life: 32 years
Treatment Service Life: 5 years

Sacramento County

Cordova Lane

Construction Date: 1966
REAS Treatment applied: May 2002
Pavement Service Life: 41 years
Treatment Service Life: 5 years





Sacramento County

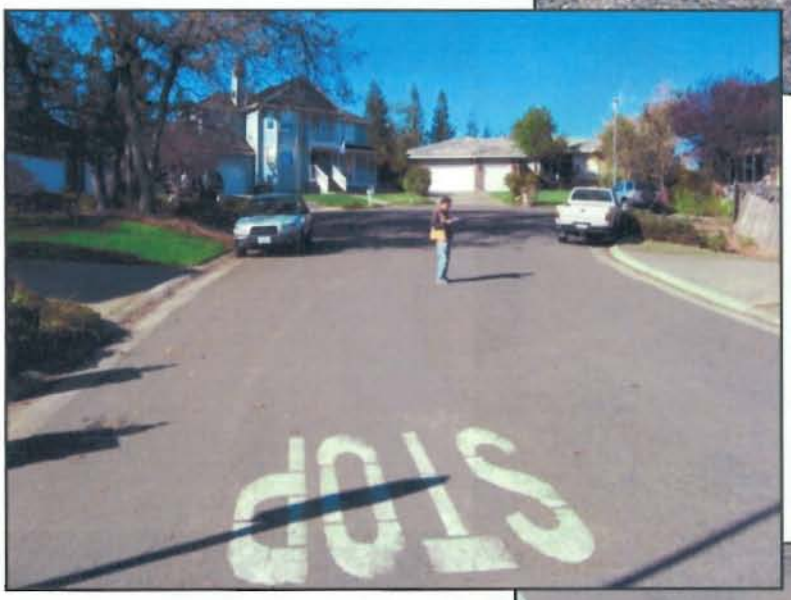
Eugenia Court

Construction Date: 1990
REAS Treatment applied: May 2002
Pavement Service Life: 17 years
Treatment Service Life: 5 years

Sacramento County

Great Dome Court

Construction Date: 1981
REAS Treatment applied: May 2002
Pavement Service Life: 26 years
Treatment Service Life: 5 years



Sacramento County

Hirschfeld Way

Construction Date: 1972
REAS Treatment applied: May 2002
Pavement Service Life: 35 years
Treatment Service Life: 5 years

Sacramento County

Long Canyon Drive

Construction Date: 1977
REAS Treatment applied: May 2002
Pavement Service Life: 30 years
Treatment Service Life: 5 years

Sacramento County

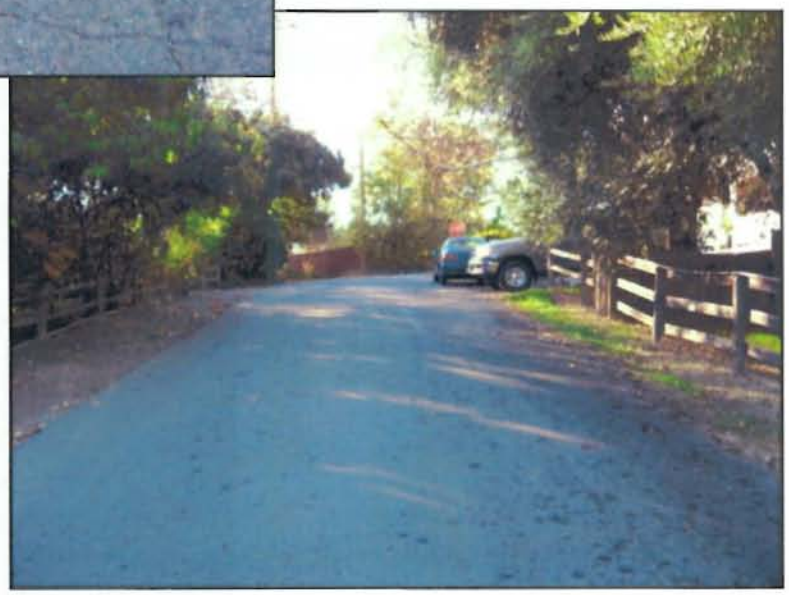
Mist Court

Construction Date: 1966
REAS Treatment applied: May 2002
Pavement Service Life: 41 years
Treatment Service Life: 5 years

Sacramento County

Orange Avenue

Construction Date: 1966
REAS Treatment applied: May 2002
Pavement Service Life: 41 years
Treatment Service Life: 5 years



Sacramento County

Quad Court

Construction Date: 1966
REAS Treatment applied: May 2002
Pavement Service Life: 41 years
Treatment Service Life: 5 years

Sacramento County

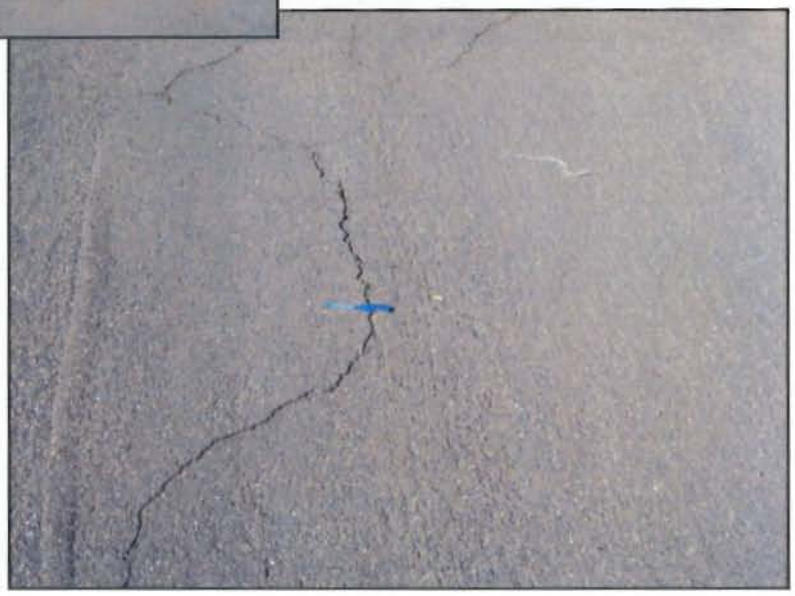
Stageline Court

Construction Date: 1977
REAS Treatment applied: May 2002
Pavement Service Life: 30 years
Treatment Service Life: 5 years

Sacramento County

Vista Dome Court

Construction Date: 1981
REAS Treatment applied: May 2002
Pavement Service Life: 26 years
Treatment Service Life: 5 years



Sacramento County

El Terraza Drive

Construction Date: 1966
REAS Treatment applied: May 2006
Pavement Service Life: 41 years
Treatment Service Life: 1 years

Sacramento County

Fairlawn Court

Construction Date: 1966
REAS Treatment applied: May 2006
Pavement Service Life: 41 years
Treatment Service Life: 1 years

Sacramento County

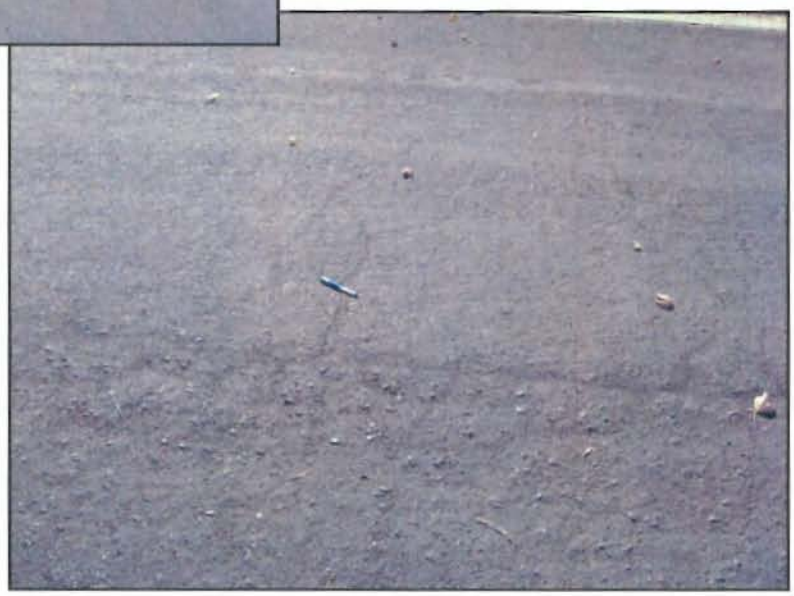
Glacken Way

Construction Date: 1966
REAS Treatment applied: May 2006
Pavement Service Life: 41 years
Treatment Service Life: 1 years

Sacramento County

Napier Way

Construction Date: 1966
REAS Treatment applied: May 2006
Pavement Service Life: 41 years
Treatment Service Life: 1 years



Sacramento County

Theodore Avenue

Construction Date: 1966
REAS Treatment applied: May 2006
Pavement Service Life: 41 years
Treatment Service Life: 1 years

APPENDIX E

PHASE III "NEW PROJECTS" APPROACH PAVEMENT EVALUATION PHOTOGRAPHS

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APPENDIX F

SLURRY SEAL SPECIFICATIONS

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City of Chula Vista

East Moss Avenue (1010)

Construction Date: August, 1950
REAS Treatment applied: October 15, 2007
Pavement Service Life: 57 years

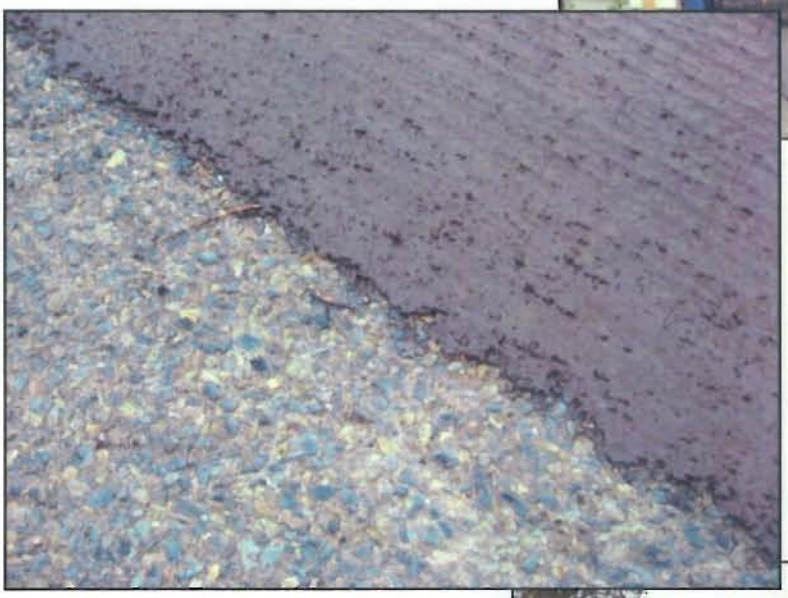
Before treatment condition photographs

City of Chula Vista

East Moss Avenue (1010)

Construction Date: August, 1950
REAS Treatment applied: October 15, 2007
Pavement Service Life: 57 years

Treatment application photographs



City of Chula Vista

Finch Place

Construction Date: August, 1970
REAS Treatment applied: October 17, 2007
Pavement Service Life: 37 years

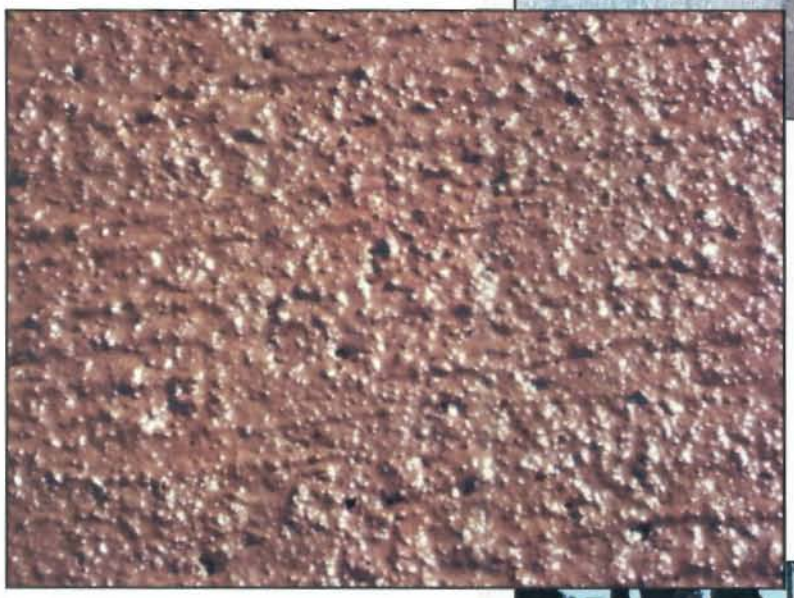
Before treatment condition photographs

City of Chula Vista

Finch Place

Construction Date: August, 1970
REAS Treatment applied: October 17, 2007
Pavement Service Life: 37 years

Treatment application photographs



City of Chula Vista

Oak Place

Construction Date: August, 1976
REAS Treatment applied: October 17, 2007
Pavement Service Life: 31 years

Before treatment condition photographs

City of Chula Vista

Lantana Avenue

Construction Date: August, 1968
REAS Treatment applied: October 17, 2007
Pavement Service Life: 39 years

Before treatment condition photographs

City of Chula Vista

Nile Avenue

Construction Date: August, 1968
REAS Treatment applied: October 15, 2007
Pavement Service Life: 39 years

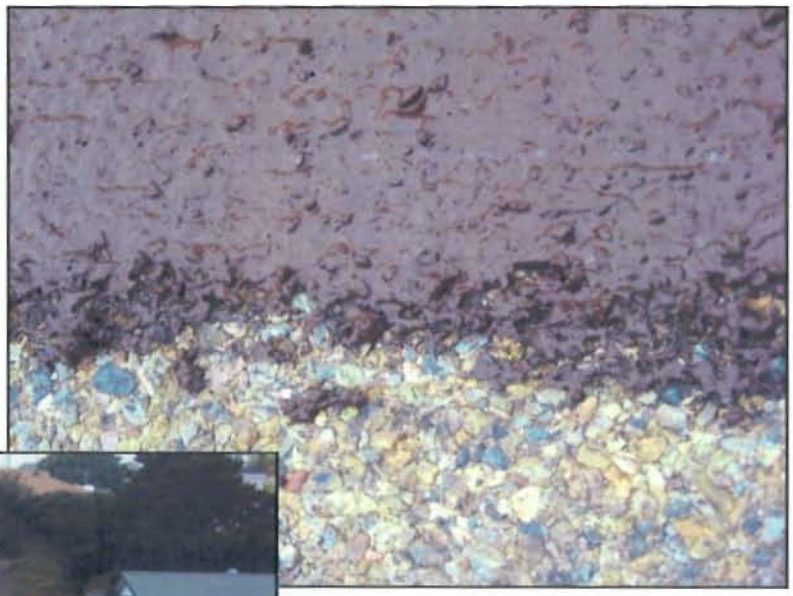
Before treatment condition photographs

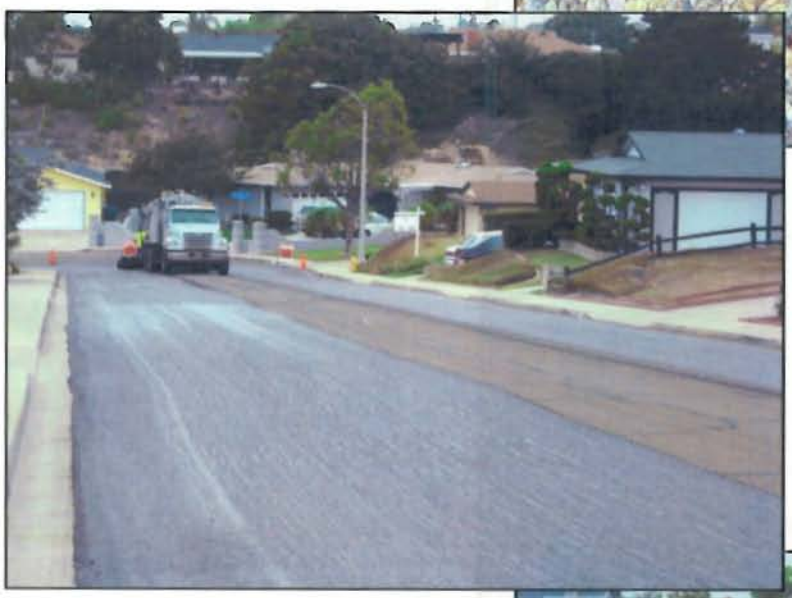
City of Chula Vista

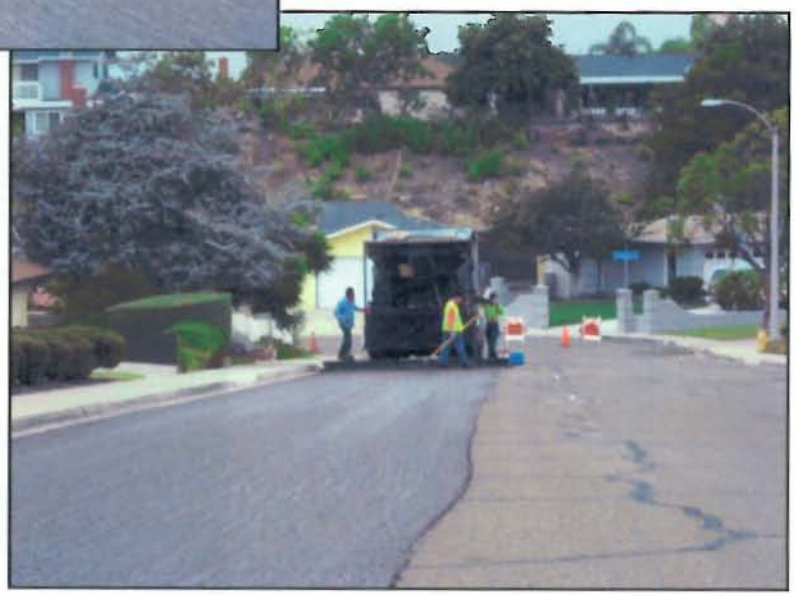
Nile Avenue

Construction Date: August, 1968
REAS Treatment applied: October 15, 2007
Pavement Service Life: 39 years

Before treatment condition photographs







Sacramento County

Rose Valley Way

Construction Date: 1979
REAS Treatment applied: May 16, 2007
Pavement Service Life: 28 years

Before treatment condition photographs

Sacramento County

Rose Valley Way

Construction Date: 1979
REAS Treatment applied: May 16, 2007
Pavement Service Life: 28 years

Treatment application photographs

Sacramento County

Tallyho Drive

Construction Date: 1977
REAS Treatment applied: May 16, 2007
Pavement Service Life: 30 years

Before treatment condition photographs

Sacramento County

Tallyho Drive

Construction Date: 1977
REAS Treatment applied: May 16, 2007
Pavement Service Life: 30 years

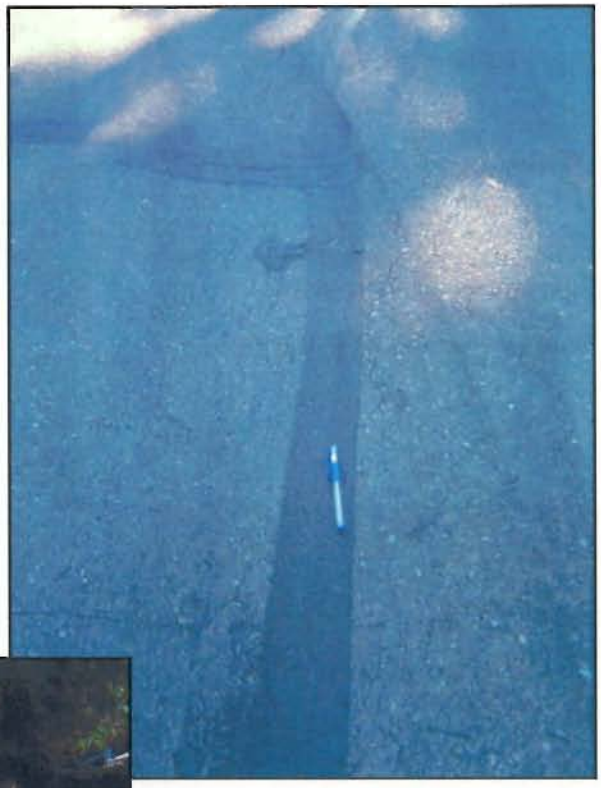
Treatment application photographs

City of Pleasant Hill

Harriet Drive

Construction Date:
REAS Treatment applied: August 9, 2007
Pavement Service Life: years

Before treatment condition photographs



City of Pleasant Hill

Harriet Drive

Construction Date:
REAS Treatment applied: August 9, 2007
Pavement Service Life: years

Treatment application photographs

File No. STL-340

CITY OF
CHULA VISTA

Contract Documents for:

REAS SLURRY SEAL PAVEMENT REHABILITATION FY 07/08
(STL-340)

THIS IS A NON-PREVAILING WAGE PROJECT

M:\General Services\Design\STL340 Pavement Rehab\STL-340 REAS Contract July 2007 final.doc

2-05 RUBBERIZED EMULSION-AGGREGATE SLURRY (REAS)

This work shall consist of formulating a mix design, cleaning pavement surfaces, mixing and applying a crumb rubber asphalt slurry-seal surface treatment and protecting the completed slurry seal until set. All work shall be according to these special provisions, and as approved by the Engineer. Rubberized Emulsion Aggregate Slurry shall be Type II for each street and the La Bellas Parking Lot.

Rubberized Emulsion-Aggregate Slurry (REAS) shall consist of Rubberized Polymer Modified Emulsion (RPME) and aggregate. Materials for REAS shall conform to the following, immediately before mixing.

The RPME shall be a quick set type of emulsion as determined by the Engineer. RPME shall contain asphalt, crumb rubber, and polymer modifiers.

Polymer modifier shall be latex, which is added at a minimum of 2 percent of weight of the RPME.

The crumb rubber material shall be granulated scrap tire rubber free from fabric wires and other contaminants. Rubber shall be dry and free flowing. Calcium carbonate or talc may be added to a maximum of 4 percent by weight of rubber to prevent rubber particles from sticking together. The rubber shall have a specific gravity between 1.15 and 1.20. One hundred percent of the rubberized material shall pass a 1.18*mm* (#16) sieve, 95% shall pass a 900μm (#20 sieve), and a maximum of 2 percent shall pass a number 75μm (#200) sieve. The RPME shall contain between 66 g/L (0.55 lbs./gal.) and 78 g/L (0.65lbs/gal.) of crumb rubber.

The manufacturers shall certify that materials meet the requirement of this specification.

TABLE 600-3.2.4(A)
TESTS ON RUBBERIZED POLYMER MODIFIED EMULSION

Viscosity, 25°C(77°F), Brookfield, Model RVT #6 Spindle @ 10 RPM (Centipoise)	2.500 min. 20,000 max.
Residue by Evaporation % (ASTM D244)	50 min.
Sieve Test % retained in #20 screen (ASTM D244)	2.0 max[1]
Weight per Gallon	1.0 kg/L(8.33 lbs./gal) min. 1.05 kg/L (8.75 lbs./gal) max.
Penetration of Residue, 25°C (77°F), 100g, 5 sec ASTM D5	20 min. - 40 max.
Percent Residue Soluble in Trichloroethylene ASTM D2042	75 min.

[1] Sieve test of original emulsion is 0.10 max.

TABLE 600-3.2.4 (B)
TEST ON POLYMER MODIFIER

Total Solids (residue) ASTM D1417	60% min.

TABLE 600-3.2.4 (C)
COMPOSITION OF REAS

Aggregate Type	RPME % of Dry Aggregate Weight	Residual RPME % of Dry Aggregate Weight	Kg of Dry Aggregate per L of RPME	Pounds of Dry Aggregate per Gallon of RPME
Fine Slurry Aggregate	60 - 80	30 - 40	1.27 - 1.70	10.6 - 14.2
Type I Slurry Aggregate	50 - 75	25 - 38	1.35 - 2.0	11.3 - 17.0
Type II Slurry Aggregate	28-35	14-18	2.90-3.60	24-30

The aggregate shall consist of sound and durable natural or manufactured sand, crushed stone or crushed stone and rock dust, or a combination thereof, free of deleterious

amounts of organic material, mica, and other substances not suitable for the purpose. Smooth-textured sand of less than 1.25 percent water absorption, as tested by ASTM C128, shall not exceed 50 percent of the total combined aggregate. Aggregate retained on the 300*μm* sieve (#50) shall be 100 percent crushed.

The combined aggregate shall meet the requirements of Table 203.5.2 (B) of the Standard Specifications before any chemical additions.

The combined aggregate shall conform to the gradation shown in Table 600-3.2.5 (A) when tested according to ASTM C136.

TABLE 600-3.2.5 (A) GRADATION OF AGGREGATES

SIEVE	FINE SLURRY AGGREGATE	TYPE I SLURRY AGGREGATE	TYPE II SLURRY AGGREGATE
	% BY WEIGHT PASSING SIEVES		
4.75 *mm* (No. 4)	100	100	90-100
2.36 *mm* (No. 8)	95 - 100	90- 100	65-90
1.18 *mm* (No. 16)	75 - 92	65 - 90	45-70
600 *μm* (No. 30)	50 - 75	40 - 60	30-50
300 *μm* (No. 50)	35 - 50	25 - 42	18-36
150 *μm* (No. 100)	15 - 30	15 - 30	10-24
75 *μm* (No. 200)	10 - 20	10 - 20	5-15

All water used in making the slurry shall be potable and free from harmful soluble salts. Additives up to 1.5 percent of the dry aggregate weight, as approved in the mix design, may be in the slurry to modify viscosity, setting, and curing characteristics. Field adjustments to additives may be made if approved by the Engineer.

Mix designs and calibrations shall be per Section 203-5.4 of the Standard Specifications and the following. Mix design results shall include any proposed additives. The completed slurry shall have a minimum skid resistance of 40 when tested per California Test No. 342. The standard Wet Track Abrasion Test (WTAT) template may be modified to a thickness of 3.18 *mm* (0.125"), when using slow-set emulsion. The mix design shall include the weight per liter (lbs. per gallon) of REAS.

The REAS shall be mixed either by a continuous flow mixer per Section 302-4.2.2 of the Standard Specifications, or a central mixing plant. A central mixing plant shall not be used for quick set REAS.

If a central mixing plant is used, combining of the RPME and aggregate in the mixing tank shall

be in the presence of the Engineer. The tank shall be calibrated in liters and gallons and equipped with load cells and a full sweep agitator capable of producing a homogeneous slurry mix. All storage tanks and delivery vehicles shall be equipped with an agitator. The REAS shall be delivered to the slurry site and spread directly behind the truck with a mechanical-type squeegee distributor, or the slurry may be pumped into smaller trucks equipped with mechanical-type squeegee distributors. All spreading equipment shall contain fog/water systems per Section 302-4.4.3.2 of the Standard Specifications. The mixing tank shall not be used to batch more than one job at a time. Storage tanks for RPME and REAS shall not be used to supply more than one job at a time.

The weight per liter of REAS delivered to the spreader box shall be within 0.11 kg/L (0.92 lbs/gal) of the mix design.

The calibration shall conform to Section 203-5.4 of the Standard Specifications, and the following: The calibration shall be per International Slurry Surfacing Association (ISSA). If the tests do not meet specification requirements, additional tests shall be performed at the Contractor's expense until an acceptable mix is obtained.

The application of REAS shall conform to Section 302-4.3.2 of the Standard Specifications, except for the following conditions, and RPME application rates specified in Table 600-3.4 (A). REAS shall not be applied when the atmospheric temperature is less than 10°C (50°F) or when the atmospheric temperature at 7:00 a.m. is 24°C (75°F) or over, and rising to a forecast high of 39°C (100°F). The total time of mixing in the slurry machine shall not exceed five minutes. Before applying slurry, the Contractor shall clean the surface to be sealed, and remove all thermoplastic striping and markings, unless otherwise specified.

TABLE 600-3.4 (A)
RPME APPLICATION RATES

Aggregate Type	Application Rate m^2/L of RPME	Application Rate ft^2/gallon of RPME
Fine Slurry Aggregate	0.86 to 0.98	35 to 40
Type I Slurry Aggregate	0.74 to 0.98	30 to 40
Type II Slurry Aggregate	0.60 to 0.74	24 to 30

Field Sampling shall conform to Section 302-4.3.3.

The Contractor shall protect all existing manhole, valve, survey monument, and other miscellaneous frames and covers. The Contractor shall cooperate with the owners of any frames and covers and shall cover and completely protect them with heavy roofing paper or other suitable material. Petroleum-based release agents shall not be used for this purpose.

Public Convenience and Traffic Control shall conform to Section 302-4.3.3 and to these Special

Provisions.

The contract unit price paid for **"Type II Rubberized Emulsion Aggregate Slurry Seal"** shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals necessary to apply the REAS as specified in the Standard Specifications and these Special Provisions, and no additional compensation will be allowed therefore. Any cleanup work due to application of emulsion or tracking caused by any vehicles or equipment shall be at the Contractor's expense. Payment reduction for noncompliance shall conform to 302-4.6.1 and 302-4.6.2 of the Standard Specifications.

2-06 CONSTRUCTION SURVEYING

This project does not require the adjusting of sewer manholes or survey monuments covers. However, any monuments destroyed by the Contractor will be replaced by the City of Chula Vista Land Surveying Group at the Contractor's expense. A forty-eight-hour advance request notice is required.

2-07 PUBLIC CONVENIENCE AND SAFETY (TRAFFIC CONTROL)

Public convenience and safety shall be according to Section 7-10 of the Standard Specifications for Public Works Construction and Regional Supplement Amendments. The Contractor shall be required to submit traffic control plans for work to be done two weeks before starting of work, for the City Engineer's approval. The Contractor shall comply with the traffic control plans. Traffic control shall conform to CalTrans "Manual of Traffic Controls," latest edition.

It is the responsibility of the Contractor performing work on a City street to install and maintain the traffic control devices and such additional traffic control devices as may be required to insure safe movement of traffic motorists, bicyclists and pedestrian through and around the work area and provide maximum protection and safety to construction workers.

The Contractor shall be responsible for preserving original locations and dimensions of all existing striping obliterated by the work. The Contractor shall be responsible for maintaining sufficient striping control points to be able to restore lane dimensions. The Contractor shall install and maintain temporary overlay yellow or white markers, whichever is applicable, where striping cannot be restored by the end of the workday.

The City Traffic Department reserves the right to observe the traffic control plans in use and to make changes as field conditions warrant. Any changes will supersede the plans and will be done solely at the Contractor's expense.

The Contractor shall notify the City Traffic Engineer at least two working days before starting any construction detour.

The Contractor shall arrange with Pacific Waste Services to maintain trash pick-up services for

COUNTY OF SACRAMENTO
MUNICIPAL SERVICES AGENCY
DEPARTMENT OF TRANSPORTATION

CONTRACT SPECIFICATIONS FOR:

GTIP PAVEMENT MAINTENANCE PROJECT 2006 - 2007

VARIOUS LOCATIONS WITHIN SACRAMENTO COUNTY

NOTE: The Standard Specifications, dated July 2002, of the California Department of Transportation, are hereby made part of these specifications. Also, the County of Sacramento Construction Specificaitons dated September 2001 (Revised March 2004) are made part of the Specifications.

BIDS OPEN: May 24, 2007

Robert F. Shanks, Interim Administrator
Municipal Services Agency

CONTRACT NO.: 3952

THOMAS J. ZLOTKOWSKI, Director
Department of Transportation

DATE: April 2007

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1.06, "Asphaltic Emulsion Binder (Tack Coat)," of these Special Provisions.

The Contractor shall remove and dispose of all pavement markers prior to the overlay. All thermoplastic limit lines, crosswalks, and legends applied to the road surface shall be scarified prior to placing the overlay. However, striping scarification shall not occur more than five (5) calendar days before paving. Excess crack seal indicated in these Special Provisions or by the Engineer shall be removed on roadways by scarification or by any method approved by the Engineer. Scarifications for deceleration zones and excess crack seal shall be paid for at the bid price for "Cold Plane Asphalt Concrete Pavement" and no additional compensation will be allowed therefor.

All manholes, utility, and survey monument covers encountered in the area to be overlaid with asphalt concrete shall be carefully referenced out prior to the overlay by the Contractor. All exposed survey monuments shall be referenced out prior to the overlay, covered by an appropriate method approved by the Engineer, and uncovered after the overlay without disturbing or damaging the survey monument.
The Contractor shall place temporary pavement delineation conforming to Section 23-8.02, "Pre-Overlay Preparation," of the Standard Construction Specifications. Temporary pavement delineation layout shall be approved by the Engineer.
The Contractor shall also place additional temporary pavement delineation deemed necessary by the Engineer for the safety of vehicular and pedestrian traffic.

Full compensation for Pre-Overlay Preparation, as specified herein, including temporary pavement delineation placement and removal shall be considered as included in the prices paid for the various items of work involved as specified in Section 8-3, "Work to be Done Without Direct Payment," of the Standard Construction Specifications and no additional compensation will be made therefor.

23-1.02 SLURRY SEAL
The work area shall include the total street section between edges of pavement or between lips of concrete curbs and gutters, or specified by the Engineer for all roadways in the "Surface Treatment List" designated to receive a slurry seal.

All necessary traffic controls, including flagmen, barricades, and cones necessary to protect the workmen and general public and to direct traffic shall be furnished and maintained by the Contractor. To avoid damage to automobiles and other personal and real property, the Contractor shall provide advance notice to adjacent residents of the work area as specified in "Construction Area Traffic Control," of the Special Provisions.

The Contractor shall use a slurry seal that permits traffic flow within one hour after placement, without the occurrence of bleeding, raveling, separation, adhering to vehicle tires, or other distress; and will not bleed, ravel, separate, or otherwise experience distress within 15 days of placement. In the event that the slurry seal shows signs of distress, the Contractor shall reseal the distressed sections at his own expense. In the event that the slurry seal fails to meet any of the specified requirements, a deduct of twenty percent (20%) of the unit price bid shall be imposed by

the County for the area over which the batch of non-conforming slurry seal was applied.

The Contractor shall develop a job mix design and present applicable test results prepared by a certified ISSA laboratory to the Engineer three days prior to the start of work. Compatibility of the aggregate and the CQS-1H shall be verified by the mix design.

The emulsified asphalt shall be designated as grade CQS-1H with liquid rubber latex additive.

The asphalt emulsion shall conform to the following specifications:

Test	Test Method	Requirement	
Tests of emulsion:		min	max
Viscosity SSF, @ 77°F, seconds	AASHTO T 59	15	90
Settlement, 5 days, %	AASHTO T 59	--	5
Storage Stability Test, 1 day, %	AASHTO T 59	--	1.0
Distillation: Oil distillate by volume of emulsion, %	AASHTO T 59	--	3
Residue by Evaporation, %	CTM 331	57	--
Tests on residue from Evaporation using CTM 331:			
Penetration, 77°F, 100 grams for 5 seconds, dmm	AASHTO T 59	40	65
Solubility in Trichloroethylene, %	ASTM D 2042	97.5	--
Torsional Recovery, %	CTM 332	18	--

Mineral Aggregate

The aggregate shall be manufactured crushed stone such as granite, slag, limestone, chat, or other high quality aggregate, or combination thereof. To assure the material is totally crushed, 100% of the parent aggregate shall be larger than the largest stone gradation to be used.

When tested in accordance to AASHTO T27 (ASTM C136) and AASHTO T11 (ASTM C117), the aggregate gradation (including the mineral filler) shall be within following bands:

Type II

Sieve Sizes	Percentage Passing	Stockpile Tolerances
9.5 mm (3/8")	100	±5%
4.75 mm (#4)	94-100	±5%
2.36 mm (#8)	65-90	±5%
1.18 mm (#16)	40-70	±5%
600 um (#30)	25-50	±5%
330 um (#50)	18-30	±4%
150 um (#100)	10-21	±3%
75 um (#200)	5-15	±2%

After the target gradation has been submitted and identified in the mix design, the percent passing each sieve shall not vary by more than the stockpile tolerance and still remain within the gradation band during the application of slurry seal.

The mineral aggregate shall also conform to the following:

Test	Test Method	Requirements
Sand Equivalent	ASTM D 2419	60 % Minimum
Loss in L.A. Rattler (100 Revolutions)	CTM 211	10% Maximum
Loss in L.A. Rattler (500 Revolutions)	CTM 211	35% Maximum
Durability Index	ASTM D 3744	60% Minimum

Mineral Filler - Mineral Filler shall be either Portland Cement, Hydrated Lime, limestone dust, flyash or other approved filler meeting the requirements of ASTM D 242 and shall be used if required by the mix design. The mineral filler shall be considered as part of the aggregate in calculations regarding slurry seal asphalt content.
Additives - Additives may be used to accelerate or retard the mixing and setting characteristics of the slurry seal, or to improve the resulting finished surface. The use of additives in the slurry mix (or individual materials) shall be made initially in quantities predetermined by the mix design with field adjustments if required. If the use of additive during application requires a greater than +/- 1.0% deviation from the recommendations of the mix design, a new mix design will be performed to verify system performance at higher or lower additive levels.

Mix Design and Pre-Qualification of Materials:
The Contractor shall submit a signed mix design covering the specific materials to be used on the project. Compatibility of the aggregate, emulsion, mineral filler, and other additives shall be verified by the mix design. The mix design shall be made with the same aggregate gradation that the contractor shall provide on the project.

The mix design shall be performed and dated within thirty (30) days prior to the application of slurry seal. This mix design testing shall be performed by a laboratory

capable of performing all tests listed in the Special Provisions. The laboratory shall certify on the mix design that it has had at least two years of experience in the design of slurry seal.

After the mix design has been approved, no substitution or changes of materials shall be permitted unless approved by the Engineer. If changes in materials are approved by the Engineer a new mix design shall be performed by the Testing Laboratory before the application of new materials.

Required test and values are as follows:

Test	Description	Spec
ISSA TB-113	Mix Time	Controllable to 180 sec min
ISSA TB-139	Wet Cohesion	
	30 minutes min	12 kg-cm minimum
	60 minutes min	20 kg-cm minimum
ISSA TB-109	Excess Asphalt by LWT Sand Adhesion	50 g/ft^2 maximum (538 g/m^2 max)
ISSA TB-114	Wet Stripping	Pass (90% min)
ISSA TB-100	Wet Track Abrasion Loss One hour soak	50 g/ft^2 maximum (807 g/m^2 max)

The wet track abrasion test is used to determine the minimum asphalt content.

The laboratory shall also report the quantitative effects of moisture content on the unit weight of the aggregate (bulking effect). The report must clearly show the proportions of aggregate, mineral filler (min. and max.), water (min. and max.), additives(s) (usage), and asphalt emulsion based on the dry weight of the aggregate.

The percentages of each individual material required shall be shown in the laboratory report. Adjustments may be required during the construction, based on the field conditions. The Engineer shall give final approval for all such adjustments.

The Engineer shall approve the mix design and all slurry seal materials and methods prior to use. The component materials shall be within the following limits:

RESIDUAL ASPHALT	7.5%-13.5% (approx. 12.0 - 22.0% emulsion) Based on dry weight of aggregate.
MINERAL FILLER	0.0% - 2.0%

	Based on dry weight of aggregate.
ADDITIVES	As needed to control mixing ad setting times.
WATER	as needed to achieve proper mix consistency.

The Contractor shall submit samples to the Engineer from all suppliers furnishing a minimum of the following materials with corresponding MSDS sheets. Each sample shall be clearly labeled as to its contents, the related project name and job number.

1) one gallon of the base asphalt
2) one pint of the polymer additive (with clear labeling of polymer type)
3) one quart of asphalt emulsion
4) 50 pounds of slurry seal aggregate

Proportioning - Proportioning shall conform to the provisions in Section 37-2.04, "Proportioning" of the Standard Specifications and these provisions.

The aggregate shall be proportioned using a belt feeder operated with an adjustable cutoff gate. The height of the gate opening shall be readily determinable. The emulsion shall be proportioned by a positive displacement pump. Any variable rate emulsion pump, if used, shall be equipped with a means to seal the adjusting unit in it's calibrated condition.

The delivery rate of aggregate and emulsion per revolution of the aggregate feeder shall be calibrated at the appropriate gate settings for each mixer-spreader truck used on the project. The calibration shall demonstrate that delivery rates of dry aggregate and emulsion residue are within the recommended percentages stated in the laboratory mix design. The Contractor shall provide written calibration documentation for each application truck, which has been performed within the last calendar year. The Contractor shall further provide a short calibration demonstrating gate settings and liquids are delivering job materials within the mix design recommended ranges.

Mixing and Spreading Equipment - Mixing and spreading equipment shall conform to the provisions in Section 37-2.05, "Mixing and Spreading Equipment" of the State Specifications and these provisions.

Placing - Placement of slurry seal shall conform to the provisions in Section 37-2.06, "placing" of the State Specifications and these provisions. When deemed necessary by the engineer, the contractor shall sand intersections to protect freshly placed slurry seal. Sand shall be free from clay or organic material and shall be of such size that from ninety to one hundred percent (90 to 100%) shall pass a No. 4 sieve and not more than five percent (5%) shall pass a No. 200 sieve. Sand shall be spread at approximately one (1) to two (2) pounds per square yard. Sand used to protect freshly placed slurry seal shall be black sand. Compensation for sanding intersections, as specified herein,

shall be considered as included in the prices paid for the various items of work involved as specified in Section 8-3, "Work to be Done Without Direct Payment," of the Standard Construction Specifications and no additional compensation will be made therefor.

Spread Rates - Ranges for spread rates shall be as follows:

Type I	10-14 lbs/yd^2
Type II	16-20 lbs/yd^2
Type III	22-26 lbs/yd^2

The exact rate will be as determined by specific weight of aggregate, the surface demand of the pavement, and the size of the largest particle size of the aggregate. The application rate will produce finished slurry seal as defined elsewhere within this Special Provision.

For all roads on the "Surface Treatment List" designated to receive a slurry seal, the slurry seal shall be placed at a rate of approximately sixteen (16) to twenty (20) pounds of aggregate per square yard

At the end of each day's production, the Contractor will send to the Engineer a report containing the following information:

1. Tons of dry aggregate consumed that day;
2. Tons of asphalt emulsion consumed that day; and
3. Square footage covered that day.

This report shall be received no later than 10:00 am of the following day.

The liquid rubber latex shall be thoroughly homogenous and shall be milled into the product at the pugmill. The percentage of liquid rubber latex to be added to the asphalt emulsion shall be two percent (2%) of the emulsion volume.
Water shall be potable and shall be free of harmful soluble salts.

Slurry seal shall be placed only when the atmospheric temperature is at least 55°F. and rising. The rate of curing of the slurry seal shall be such that a street may be open to traffic within one hour after application without tracking or damage to the surface.
Slurry seal shall be mixed in continuous pugmill mixers. Concrete transit mixer trucks shall not be used. There shall be a minimum of two 7 cubic yard or larger slurry machines on the job site and in good operating condition at all times.

Slurry seal may not be applied over or against concrete curbs. The Contractor shall furnish and maintain in good operating condition all tools and equipment necessary to do the work with a minimum of inconvenience to the public, and shall employ sufficient personnel to operate all equipment efficiently and skillfully.

The Contractor shall refrain from using diesel fuel or solvents of any kind for cleaning tools and equipment in such a manner as to permit spillage on new or existing

pavement, curbs, gutters, parkways, or other improved areas nor shall such fluids be washed, flushed, or allowed to enter the storm drain or sewer systems.

Random samples of slurry shall also be taken and verification made as to mix consistency, proportioning, and conformance to the job mix design.

Quality Control Plan:
The Contractor shall implement a Quality Control Plan (Plan) by the establishment of a quality control organization. The cost of the Plan shall be the responsibility of the Contractor.

The Contractor shall assign a Plan Administrator responsible for implementing the elements of the Plan, including the quality control testing portion. The Plan Administrator shall be an authorized representative designated by the Contractor who shall have the authority to represent and act for the Contractor.

The Plan shall provide for a fully equipped Testing Laboratory. It shall be AASHTO accredited for ASTM D3666. As indicated on the AASHTO accreditation, the laboratory shall be certified for the ASTM and AASHTO test methods listed herein and it shall be equipped with the necessary testing equipment to perform the tests required in the Quality Control Plan.

The Engineer shall be permitted unrestricted access to inspect the Testing Laboratory's facility and witness quality control testing activities and compliance with the contract specifications.

The Testing Laboratory shall provide a sufficient number of Quality Control Technicians to implement the Plan. Quality Control Technicians shall be either engineers, engineering technicians (NICET Level I or higher) in the field of engineering and shall have a minimum of one year of experience in this area of expertise.
The Engineer shall advise the Contractor in writing of any noted deficiencies concerning the Testing Laboratory's certifications, equipment, supplies, or testing personnel and procedures. When deficiencies are noted, the Engineer shall suspend the application of slurry seal until the noted deficiencies are corrected to the satisfaction of the Engineer.
The Plan shall be organized to address the following and be submitted for approval during the pre-construction meeting:

1) Name of Contractor's Plan Administrator;
2) Name and location of the Testing Laboratory or facility;
3) Names and qualifications of the quality control testing personnel;
4) Tests to be performed by the Testing Laboratory and frequency of testing during slurry seal application.
5) Procedure for submitting tests results to the Contractor and the Engineer;
6) Written statement on laboratory letterhead that the Testing Laboratory is equipped with the required testing equipment, and the equipment is calibrated in conformance with ASTM standards or other applicable standards; and

7) A copy of the Testing Laboratory's AASHTO accreditation of ASTM D3666.

The minimum acceptable testing and minimum acceptable testing frequency noted in the Quality Control Plan shall be as follows:

Asphalt Emulsion (minimum testing frequency - once daily)

Residue by Evaporation, %	CTM 331
Tests on residue from Evaporation using	CTM 331:
Penetration, 77°F, 100 grams, 5 sec, dmm	AASHTO T 59
Torsional Recovery, %	CTM 332

Samples of asphalt emulsion for slurry seal shall be captured from the storage tank of a slurry seal application truck and performed in accordance with AASHTO T 140. The Contractor shall deliver the samples to the Testing Laboratory within 24 hours of sample capture.

Mineral Aggregate (minimum testing frequency - once weekly)

Gradation	CTM 202, AASHTO T11, T27 ASTM C117, C136
Sand Equivalent	ASTM D2419
Moisture Content	CTM 226, 231/AASHTO T265/ASTM D2216

Samples of aggregate for slurry seal shall be captured from a slurry seal application truck in accordance with AASHTO T140. The Contractor shall deliver the samples to the Testing Laboratory within twenty-four (24) hours of sample capture.

Handling of Quality Control Samples and Test Reports. Samples of asphalt emulsion and mineral aggregate shall be delivered to the Testing Laboratory by the Contractor within twenty-four (24) hours of sample collection. Sample containers shall be clearly labeled with the Contractor name, job number, date/time of collection and location of sample collection. The laboratory shall report results of the testing within twenty-four (24) hours of receipt of the samples.

Test results shall be reported on the Testing Laboratory's letterheads and signed by the Laboratory's authorized representative. The Contractor name, job number, date/time of collection and location of sample collection shall be noted on the report. The test report shall be provided via facsimile to both the Contractor and the Engineer within twenty-four (24) hours of receipt of the samples. Hard copies of test results shall be provided to the Contractor via postal service. The Engineer or his representative shall be

permitted to take samples of materials from the project. The County may elect to perform Quality Assurance testing on the sample to verify results reported in the Quality Control Plan. The County Quality Assurance Testing Laboratory shall meet the identical requirements defined for the Quality Control Laboratory described elsewhere in the Special Provisions.

Measurement and Payment:
The contract unit price paid per SQUARE FOOT of Slurry Seal shall include full compensation for furnishing all labor, materials, tools, equipment, incidentals, and for doing all work involved in preparing, pavement sweeping, mixing and applying materials, quality control plan, test design, and cleanup as shown on the plans, as specified in the Standard Construction Specifications, these Special Provisions, and as directed by the Engineer and no additional compensation will be made therefor.

23-1.03 TYPE "A" ASPHALT CONCRETE
General:
Asphalt concrete shall conform to Section 23, "Asphalt Concrete," of the Standard Construction Specifications and these Special Provisions. Asphaltic emulsion shall be applied and shall conform to Section 23-1.06, "Asphaltic Emulsions Binder (Tack Coat)," of these Special Provisions.

The minimum compacted thickness of asphalt concrete shall be the thickness described in these Special Provisions. The minimum and maximum tolerance for asphalt concrete thickness shall be 0.01 ft. The tolerance for asphalt concrete placed adjacent to concrete curb and gutter shall be a minimum of flush to the lip of gutter to a maximum of 0.01 ft higher than the lip of gutter.

Emulsion shall be applied to both the vertical edges of the existing pavement and to the pavement to be surfaced prior to placing new asphalt concrete. Asphaltic emulsion shall conform to "Asphaltic Emulsions Binder (Tack Coat)" of these special provisions and shall be included in the unit bid price for asphalt concrete and no additional compensation shall be allowed therefore.

The paving asphalt specified shall comply to Section 92 "Asphalts" of the May 2006 State Standard Specifications. The amount of asphalt binder will be determined by the Contractor in accordance with CAL 367. Tolerance upper and lower limit will be determined to meet stability air voids and potential flushing requirements.

The Contractor's attention is specifically directed to Section 23-8.05, "Compacting," of the Standard Construction Specifications and Section 39-6.03, "Compacting," of the State Specifications for compacting finished surface requirements.

Asphalt Concrete for Paving:
Type "A" asphalt concrete should be used, and the paving asphalt should PG64-10. The aggregate gradation shall be one-half (1/2") maximum, medium gradation.

Measurement and Payment
The contract unit price paid per EACH of Install Speed Lump shall include full compensation for furnishing all labor, materials, tools, equipment, incidentals, and for doing all work involved in constructing asphalt concrete speed lumps including but not limited to asphaltic emulsion (tack coat), bollards, and striping as shown in the plans, as specified in these Special Provisions, and as directed by the Engineer and no additional

4. The following Section shall be added to "SECTION 23, ASPHALT CONCRETE"
Section 23-1.08 Rubberized Slurry Seal
Rubberized Slurry Seal shall conform to Section 600-3, "Rubberized Emulsion—Aggregate Slurry," of the 2006 version of the Standard Specifications for Public Works Construction ("Greenbook 2006") and these Special Provisions except that Sections 600-3.6, "Public Convenience and Traffic Control" and 600-3.7, "Measurement and Payment," of the Greenbook 2006 shall not apply.

The Aggregate Type for the Rubberized Slurry Seal shall be Type I Slurry Aggregate.

The work area shall include the total street section between edges of pavement or between lips of concrete curbs and gutters, or specified by the Engineer for all roadways in the "Surface Treatment List" designated to receive a rubberized slurry seal.

All necessary traffic controls, including flagmen, barricades, and cones necessary to protect the workmen and general public and to direct traffic shall be furnished and maintained by the Contractor. To avoid damage to automobiles and other personal and real property, the Contractor shall provide advance notice to adjacent residents of the work area as specified in "Construction Area Traffic Control," of the Special Provisions.

The Contractor shall use a rubberized slurry seal that permits traffic flow within one hour after placement, without the occurrence of bleeding, raveling, separation, adhering to vehicle tires, or other distress; and will not bleed, ravel, separate, or otherwise experience distress within 15 days of placement. In the event that the rubberized slurry seal shows signs of distress, the Contractor shall reseal the distressed sections at his own expense. In the event that the slurry seal fails to meet any of the specified requirements, a deduct of twenty percent (20%) of the unit price bid shall be imposed by the County for the area over which the batch of non-conforming slurry seal was applied.

The Contractor shall develop a job mix design and present applicable test results prepared by a certified ISSA laboratory to the Engineer three (3) days prior to the start of work

Asphalt Concrete for Base Repair:
A ¾" intersection (or high stability) asphalt concrete mix shall be used for all base repair locations. The mix design shall be the following or an approved equal:

Sieve Size	Percent Passing
1" (25 mm)	100
¾" (19mm)	95 - 100
3/8" (9.5mm)	53 - 65
No. 4 (4.75mm)	35 – 49
No. 8 (2.36mm)	22 – 32
No. 16 (1.18 mm)	14 – 24
No. 30 (600 μm)	9 – 17
No. 200 (75 μm)	3 – 7

The paving asphalt shall be PG70-10.

Asphalt Concrete Adjacent to Curb, Gutter, and Sidewalk:
Type "A" asphalt concrete shall be used, and the paving asphalt shall be PG64-10. The aggregate gradation shall be one-half inch (1/2") maximum, medium gradation.

Leveling Course
Only where ordered by the Engineer, an asphalt concrete leveling course shall be spread upon the existing roadbed, subbase, base, surfacing, or pavement, as specified by the Engineer and in accordance with the specifications for asphalt concrete. The leveling courses shall be Type "A" asphalt concrete with three-eighths inch (3/8") inch maximum aggregate gradation, and the paving asphalt shall be PG64-10.

At locations where the leveling course thickness exceeds three inches (3"), the leveling course shall be placed in lifts not exceeding three inches (3"). For project locations with pavement reinforcing fabric, leveling course material shall be placed prior to the placement of the fabric. The leveling course shall be paid for at the contract unit price per ton of Type "A" Asphalt Concrete (Paving)—or Type "A" Asphalt Concrete (Base Repair and Curb and Gutter) when no Type "A" Asphalt Concrete (Paving) bid item is present—and no additional compensation will be made therefor.

Measurement and Payment:
The contract unit price paid per TON of Type "A" Asphalt Concrete shall include full compensation for furnishing all labor, materials, tools, equipment, incidentals, and for doing all work involved in the production, delivery, and placement of asphalt concrete as shown on the plans, as specified in the Standard Construction Specifications, these Special Provisions, and as directed by the Engineer and no additional compensation will be made therefor.