Evaluation of RAC-O-HB Project
SAC 99-0.8/2.8

Sutterville Overpass Looking South

Report Number: CP2C- 2007 - 101

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California Pavement Preservation Center
203 Langdon Hall
California State University
Chico, California 98929-0930
(530) 898-6032

PROJECT SUMMARY PAGE	Technical Report: CP2 – 2007 - 101
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Author: Hicks. R.G.	
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Prepared by: R. Gary Hicks California Pavement Preservation Center California State University, Chico Chico, CA 95929-0930	**Date:** March 15, 2007
Abstract: This report documents the performance of a Rubberized Asphalt Concrete Open-Graded High Binder (RAC-O-HB) project placed on SAC 99 over the existing portland cement concrete lanes from Oak Park Interchange at US-50 to Martin Luther King Boulevard (northbound and southbound). in District 3 in 1999. Time constraints during construction prevented the full repairs of the PCC from being completed. Difficulties in obtaining the high binder content needed for this type of mix is likely responsible for the raveling of mix. However, the surface mix is still well bonded to the PCC and withstanding high traffic volumes.	
Keywords: Rubberized Asphalt, RAC-O-HB, Thin Surface Treatments	

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DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The contents do no necessarily reflect the official views or polices of the State of California or the Federal Highway Administration

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1.0 INTRODUCTION

This report documents the performance of a Rubberized Asphalt Concrete Open-Graded High Binder (RAC-O-HB) project placed on SAC 99 in District 3 in 1999. The report focuses on the design, construction and performance of the project. Information in this report was compiled from the following list of historical data related to the project:

- Northern Region Materials Lab (NRML)Technical Report, December 23, 1999
  1. NRML Project Report
  2. Asphalt Concrete Mix Design Results
  3. Resident Engineers Daily Reports
  4. Daily Asphalt Concrete Plant Reports
  5. Asphalt Concrete Extraction Test Results
  6. Field Study Review dated October 26, 1999
- Email notes from Gary Hildebrand (March 1999 to December 1999)
- Site Visit to RAC-O-HB projects, March 1 2007

1.1 DEFINITIONS

Rubberized asphalt concrete (RAC) is a material produced for hot mix applications by mixing asphalt rubber with graded aggregate. RAC-O indicates that asphalt rubber is mixed with open-graded aggregate; RAC-O-HB indicates that asphalt rubber is mixed with open-graded aggregate, but with a higher binder content.

The primary difference between RAC-O and RAC-O-HB is the features or functions they provide. RAC-O provides a durable, highly flexible pavement surface with enhanced drainage and frictional characteristics, reduces splash and spray to improve visibility during wet weather, reduces hydroplaning in wet conditions to reduce potential for skidding, provides increased resistance to reflective cracking and oxidation, and provides a smooth ride. RAC-O-HB is used mainly to restore surface friction and provide improved resistance to fatigue and reflective cracking, as well as to stripping and oxidative aging. These features increase the durability of the pavements.

The other difference is the binder content. RAC-O is designed using the California Test 368 with asphalt rubber binder content set at 1.2 times the optimum neat asphalt binder content with a check test for drain off. RAC-O-HB is designed according to the RAC-O procedure, but the multiplier for asphalt rubber binder content is increased to 1.6. Generally, RAC-O-HB mixes have at least 8.5 % binder by weight of the dry aggregate.

RAC-O-HB mix offers many benefits to the user. It can provide the following attributes:

- Noise reduction over concrete pavements. This has been proven in the state of Arizona.
- Improved durability and resistance to reflection cracking. However, when placed over badly distressed pavement, surface preparation work must be undertaken.

1.2 BACKGROUND

The scope of this project was to reconstruct the Route 99 median and add a HOV lane (northbound and southbound) and to convert the number 1 lanes on route 50 (northbound and southbound) to HOV lanes. The following is a list of events in chorological order:

Table 1-1 Project Events

Date	Description
July 14, 1993	First project development team meeting
August 24, 1994	The PSR for the project was approved
July 29, 1996	The draft project report received approvals
July 10, 1997	Representatives from the NRML and Translab discussed paving temperatures outlined in the SSP
October 10, 1997	The project was advertised
December 10, 1997	Granite Construction Company was awarded the bid
April 1, 1998	The project work started. The draft plans called for a 25 mm RAC-O mix
March 1999	After the contract was let, HQ maintenance requested the RAC-O mix be changed to a RAC-O-HB
July 9, 1999	Dryer drum plant calibrated
July 19-August 3, 1999	Production and paving of the RAC mix started
October 26, 1999	Field review
December 23, 1999	NRML technical report developed
March 1, 2007	Field review

The draft plans called for a 25 mm Rubberized Asphalt Concrete Open Graded (RAC-O) overlay covering the new inside lanes and the existing portland cement concrete lanes from Oak Park Interchange at US-50 to Martin Luther King Boulevard (northbound and southbound).

On July 10, 1997, representatives from the NRML and Translab discussed paving temperatures outlined in the SSP's to allow a temperature modification in the RAC-O mix. The new specification would require a minimum air temperature of 18°C instead of 13°C prior to the placement of any RAC-O mix. The modification was approved and the contract was let.

In March 1999, after the contract was let, HQ maintenance requested the RAC-O mix be changed to a RAC-O-HB. The apparent reason for this change was that Gary Hildebrand (HQ maintenance) and Jack Van Kirk (Translab) thought the RAC-O-HB mix would perform better under the prevailing pavement conditions**.** The optimum binder content (OBC) for the mix was determined to be 7.95% following the Caltrans mix design procedure. However, the RAC-O-HB specifications stated that the binder content should be 8.5% minimum. Upon approval of the North Region DME, Granite Construction was directed to use 8.0% as the OBC for the RAC-O-HB mix for this project. The binder content was felt to be too low by Hildebrand and Van Kirk. They felt the higher binder content was needed, but their recommendation was not adopted. In essence, the mix placed did not meet the specifications of a RAC-O-HB mix and is of a RAC-O mix rather than a RAC-O-HB mix.

Prior to paving, the contractor was directed to repair the existing portland cement concrete surface (spalls, corner breaks, longitudinal and transverse cracking and potholes) at the locations

receiving the RAC-O-HB mix. Due to equipment and manpower constraints, Granite was only able to complete work on the northbound side of the project. Caltrans forces were brought in to complete the southbound portion of the work. Lanes 1 and 2 were sporadically repaired and lanes 3 and 4 were left as is due to scheduling constraints. According to notes from Gary Hildebrand, the repairs were not adequate. Several of the slabs should have been replaced and crack sealing did not take place. Despite this, the RAC-O-HB mix was placed on the existing concrete pavement.

According to the resident engineer (RE), paving problems were encountered with the RAC-O-HB mix and were difficult to overcome. Raking and spreading the mix was difficult as the mix was sticky and not workable. With maximum allowable temperatures (163°C), the RAC-O-HB mix would set up on the surface, but stay pliable inside. The RE indicated the blemishes were caused by the paving equipment as the mix would stick to rubber tires from the construction equipment. The field study review conducted by the NRML noted that the north end of the southbound lanes had a higher incidence of surface blemishes than the rest of the project.

2.0 CONSTRUCTION

2.1 OVERVIEW

The asphalt concrete for this project was produced at the Granite plant on Bradshaw road in Sacramento. For the RAC portion of the project, they utilized a dryer drum plant which was calibrated in accordance with CTM 109 on February 24, 1999. The rubber blending plant was calibrated on July 9, 1999. Production and paving of the RAC mix took place between July 19 and August 3, 1999. A total of about 9,066 tonnes of RAC mix was produced and placed for this project. Asphalt content was sampled daily in accordance with Caltrans specifications, Section 39. Extractions to determine the binder content was performed by the NRML in Marysville and the Translab. The extractions indicated that the binder content ranged from 7.0 to 8.2% with most of the extractions between 7.5 and 7.9%. Granite paved the northbound lanes during the first 4 nights and the southbound lanes the last 5 paving nights. Details for each paving day are available in the NRML technical report. The air temperatures varied from 13°C to 34°C, where most nights experienced a low temperature of 13-14°C, which was below the recommend limit of 18°C.

2.2 FINDINGS

NRML developed the following list of findings and presented them in their technical report:

- Standard practice for D3 materials is to place HMA on distressed PCC pavements when thin lifts (30mm) are required. RAC-O was originally recommended.
- The RAC-O item was changed to RAC-O-HB under a contract change order.
- Different oils were reportedly used for the RAC-O-HB mix design and the production runs. This could affect the OBC for the mix if this was the case.
- The preparation work for the existing PCC pavement was not completed or sufficient prior to placing the RAC-O-HB mix.

- Temperature requirements were reviewed at the beginning of production. For example, a 3°C change in the temperature of the RAC could cause the handling and placement condition to change.
- The rubber tires on the construction equipment picked up the RAC-O-HB mix. Traffic movements (turning and merging) also caused damage to the RAC-O-HB mix.
- Traditional construction techniques hampered placement of the RAC-O-HB mix.

2.3 CONCLUSIONS FROM THE NRML TECHNICAL REPORT DATED DEC. 23, 1999

Initial conclusions, based on the investigation and field reviews performed within 4 months after placement, were as follows:

- The project lacked the proper conditions for a product of this type to be placed successfully.
- The RAC mix was subjected to harsh construction conditions. A more friendly environment may have resulted in better results.
- Choosing a viable mix type for this project should take place in the design, not during the construction phase.
- The stringent temperature requirements for RAC mixes should be discussed with construction personnel. Temperatures were reportedly not well enforced. This is particularly important for RAC mixes.
- Limiting rubber wheeled traffic on RAC mixes needs to be addressed.
- The project location should be accessible from both ends of the paving limits and should be in areas of low ADT.
- The project should be reviewed again in 2 years. However, no evidence of this review could be found.

2.4 NOTES FROM GARY HILDEBRAND (1999)

Based on an independent review of Gary Hildebrand (while he still worked for HQ maintenance), he indicated that several things could be learned from this project:

- Slab repair. The preparation of the existing slab was not adequate. Slab removal, corner break repairs, crack sealing, spall repairs and lane joint alignment all could have affected the initial performance of the project. The southbound lanes received the most repairs.
- Binder content. The binder content used in the RAC-O-HB mix was not representative of a typical RAC-O-HB mix. The recommended OBC was reportedly based on lab results only and not on past field studies.
- Longitudinal joints. They should be paved so they match with the new lane lines. Reportedly, this did not occur and in many areas the wheel paths on cold joints. This could have contributed to some of the raveling.
- Paving sequence. The contractor was told to pave full width of the roadway (multiple lanes) each night. It would have been better to pave each lane the entire length of the project and to do a new lane each night.

- Sanding. It was not required on this job prior to allowing traffic onto the mat because of the cool temperatures at night. Sanding is essential to prevent pick up from not only the contractor vehicles at night, but also vehicles of the traveling public during the next day.

Hildebrand indicated in his notes that if one does the right thing at the right time and at the right location, one can have success. However, it still has to be done in the right way. In his opinion, the RAC-O-HB mix on this project was not placed in the right way.

3.0 THE INITIAL 1999 PERFORMANCE REVIEW

The initial performance review of the project indicated that the RAC-O-HB mix experienced blemishes due to pick up under rubber tires. There were no reports of raveling according to the NRML technical report.

On March 1, 2007, a review of the pavement condition was made to determine the current performance of the mix after nearly 7 years of service under heavy traffic conditions. The project was reviewed by Dr. Gary Hicks, technical director of the California Pavement Preservation Center and Mr. Gary Hildebrand, the industry co-chair of the Pavement Preservation Task Group (PPTG). The results of the review indicated the following:

- Despite the lack of surface preparation of the existing concrete pavement, the RAC-O-HB mix is still performing.
- Surface distress from the underlying concrete is reflecting through the RAC-O-HB mix.
- Where RAC-O-HB mix and conventional HMA were placed adjacent to each other, the RAC-O-HB mix has performed much better than the conventional HMA mix.

Selected photos from this project are given in Appendix A. It should be noted that sometime after this project was placed, a spill from an accident occurred northbound on 99 just prior to the 50/80/99 interchange and was reported by Gary Hildebrand. He indicated if the spill was gasoline or diesel, the pavement could ravel. The location of the spill was found and the pavement is still in place.

4.0 PERFORMANCE OF RAC-O-HB PROJECTS IN CALIFORNIA

Several other projects have been constructed with RAC-O-HB mixes in California and have performed extremely well. A summary of the projects is given in Table 4-1 below. Selected photos from the FRE 5 project listed below are included in Appendix B.

Table 4-1 Summary of RAC-O-HB Projects in California

Project	PM	Lane Miles	Date Const	Current Condition
SAC 99	21.6-24.6	3 miles	1999	Fair condition
FRE 5	0-38	165	2000	Good condition
MONO 395	76.0-84.5	8.5 miles	2000	Small thermal cracks, performed well
MONO 395	106.3-108.0	1.7 miles	2000	Small thermal cracks, overlaid with ARGG as part of a larger project
SBD 40	3-15	112	2002	Good condition
SBD 40	73.4-89.5	112	2002	Good condition

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The preliminary review of the information on this project indicates that the following conclusions are warranted:

- HQ Division of Maintenance recommended that RAC-O-HB be used to overlay the distressed PCC pavement until the pavement could be rehabilitated. However the mix placed did not completely conform to a typical RAC-O-HB mix design. It is a RAC-O mix in terms of materials properties.
- The current performance of the RAC-O-HB mix on this project is fair. Considering the pavement on which it has been placed, it has performed extremely well.
- RAC-O-HB projects placed elsewhere in the state have also performed well.
- The RAC-O-HB mix placed on the SAC-99 project exhibited some early distress due to pick up under rubber tires. However, the type and extent of the initial distress were not well documented.
- D3 personnel felt this was not the correct treatment of the job. However HQ personnel from Translab and Maintenance (Hildebrand and Van Kirk) suggested that the job was not constructed in the correct manner.
- When designed and placed in the proper manner, the RAC-O-HB mixes seems to offer Caltrans some real benefits.

5.2 RECOMMENDATIONS

The following recommendations from this review appear warranted:

- Lessons learned from this project need to be clearly communicated and not repeated. This included properly preparing the underlying pavement prior to placing any overlay treatment.
- When the RAC-O-HB mix is considered for a project, a correct mix design and proper construction sequences must be developed.
- Specifications for RAC-O-HB mixes need to be strictly enforced.
- Although RAC-O-HB mixes have been used successfully on several Caltrans projects, they may not be appropriate for all applications because of project location and temperature requirement constraints.

APPENDIX A

Selected Photos from the SAC-99 Project (March 1, 2007)

Shoulder is a conventional mix

APPENDIX B

Selected Photos from the Fresno I-5 Project (March 1, 2007)

Reflective cracking from slab