FINAL MATERIALS REPORT
COLD FOAM ASPHALT MIX DESIGN
SR 32 Widening Project

03-But-32
From SR 99 to Yosemite Drive
PM 10.14/12.65
EA: 1E-4900

Prepared by:

BLACKBURN CONSULTING
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November 2, 2010

Prepared for:

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Geotechnical ▪ Construction Services ▪ Forensics

File No. 1202.5
November 2, 2010

Mr. Matt Brogan
Mark Thomas & Company, Inc.
7300 Folsom Boulevard, Suite 203
Sacramento, CA 95826

Subject: **FINAL MATERIALS REPORT**
COLD FOAM IN-PLACE RECYCLING
SR 32 Widening Project, 03-But-32
SR 99 to Yosemite Drive, PM 10.14/12.65
EA: 1E-4900
Chico, California

Dear Mr. Brogan,

Blackburn Consulting (BCI) is pleased to submit this Final Materials Report for the Cold Foam In-Place Recycled (CFIPR) asphalt mix design associated with the State Route 32 Widening project in Chico, CA. BCI prepared this report in accordance with our August 10, 2010 agreement. This report defines the material conditions as evaluated from field and laboratory test data, and provides CFIPR recommendations and specifications for project design and construction.

Thank you for selecting BCI to be on your design team. Please call if you have questions or require additional information.

Sincerely;

BLACKBURN CONSULTING

REGISTERED PROFESSIONAL ENGINEER
BENJAMIN D. CRAWFORD
No. GE 2861
GEOTECHNICAL
STATE OF CALIFORNIA

Benjamin D. Crawford, P.E., G.E.
Principal

Reviewed By:

FOR

Rick Sowers, P.E.
Principal

FINAL MATERIALS REPORT
COLD FOAM IN-PLACE RECYCLING
SR 32 Widening Project, 03-But-32
SR 99 to Yosemite Drive, PM 10.14/12.65

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1 INTRODUCTION

1.1 Scope of Services

To prepare this report, BCI:

1. Reviewed preliminary project plans provided by Mark Thomas & Company, Inc. (MTCo).
2. Reviewed BCI's Draft Geotechnical and Materials Report for State Route 32 (SR 32) dated May 14, 2010.
3. Reviewed Chec Management Systems, Inc. report titled "Deflection Testing and Analysis, SR 32 Widening Project," dated March 2010, job number 09079.
4. Observed the existing pavement conditions in nine test pits within the existing travel way on August 17, 2010.
5. Performed laboratory testing on the Aggregate Base samples obtained from the exploratory borings.
6. Reviewed Condor Earth Technology, Inc. October 28, 2010 "Results of Cold Foam Asphalt Mix Design," report.
7. Consulted with Julia Rockenstein, Assistant District Materials Engineer, Caltrans – Marysville.
8. Performed engineering analysis and calculations.

1.2 Project Description

The SR 32 improvement project will widen and improve about 2.5 miles of mainline State Route 32 (SR 32) from the SR99/SR32 interchange (Station 92+00, PM 10.14) to about 1,400 ft east of Yosemite Drive (Station 224+50, PM 12.65). Deflection testing and coring completed by Chec Management Systems, Inc. (CHEC) resulted in higher than expected overlay recommendations for SR 32. Therefore the City of Chico has elected to rehabilitate existing SR 32 using Cold Foam In-Place Recycled Asphalt (CFIPR).

Caltrans recently performed an overlay from SR 99 (Station 92+00) to Station 114+00; however we understand that CFIPR may be performed in this area as part of this project or during a later phase. This report provides CFIPR rehabilitation recommendations for mainline SR 32 between Stations 92+00 and Station 224+50. We show the complete project area on Figure 2 in Appendix A.

MTCo indicates the 20-year design Traffic Indices for this project is 10.5 along mainline SR32.

2 LABORATORY TESTING

BCI previously obtained near-surface (upper 5 feet) soil samples at various locations along the SR 32 shoulder for R-value testing during preparation of our Materials Report for the widening project. The results of the R-value tests range from 19 to 29. During our recent fieldwork we collected samples of the existing AC, base, and subgrade for laboratory testing. Based on the previous R-value results and the encountered subgrade materials, we selected a subgrade R-value of 22 for this CFIPR project. Grainsize and sand equivalent tests on the existing base indicates that the base meets Caltrans aggregate subbase (ASB). Therefore for this report we analysis the existing base as an ASB with a gravel factor of 1.0.

The laboratory test results are included in Appendix B.

3 EXISTING PAVEMENT

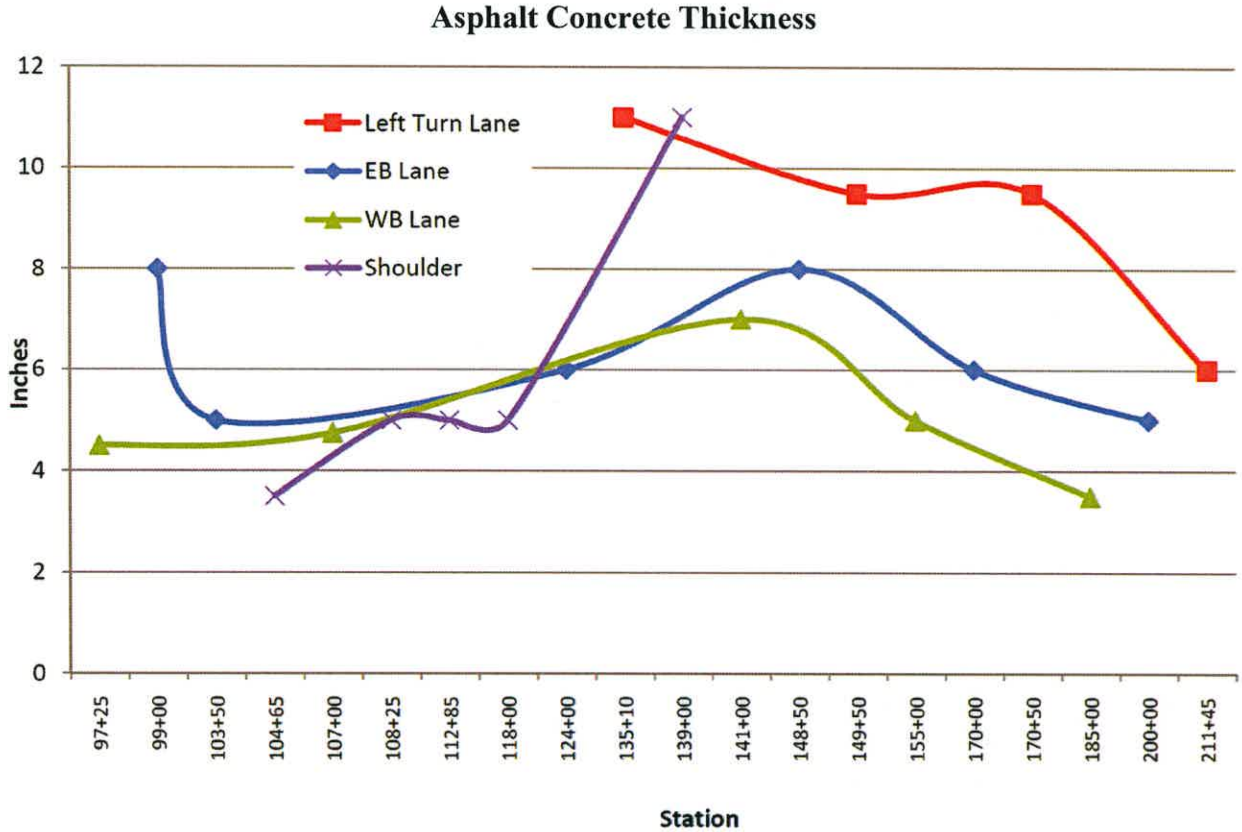
We summarize the pavement sections encountered in our test pits in Table 1. We show the test pit locations on Figure 2 in Appendix A.

Table 1: Existing Pavement Sections

Test Pit Number	Location (Station)	AC (in)	Base (in)	Subgrade
TP-1	211+45	6	15.5	Silty Gravel with Sand
TP-2	170+50	9.5	9.5	Silty Gravel with Sand
TP-3	149+50	9.5	24+	N/A
TP-4*	139+00	11	0	Lean Clay with Gravel
TP-5	135+10	11	15.5	Sandy Lean Clay with Gravel
TP-6*	118+00	5	14.5	Sandy Lean Clay with Gravel
TP-7*	112+85	5	12	Sandy Lean Clay with Gravel
TP-8*	108+25	5	14.5	Lean Clay with Gravel
TP-9*	104+65	3.5	18	Lean Clay with Gravel

**Due to Caltrans requirements these test pits were located in the shoulder.*

We summarize the asphalt thicknesses encounter during our fieldwork and those provided by CHEC during deflection testing and coring, in the figure below.



4 LABORATORY CFIPR MIX DESIGN

During our fieldwork BCI obtained samples of the existing pavement section (AC, Base, and subgrade) at nine locations for laboratory CFIPR mix design. Condor Earth Technologies, Inc. (Condor) mixed the collected AC and Base with Portland Cement Type II and PG 64-22 asphalt binder. Based on the relative quantities of the AC and Base encountered in the test pits, CFIPR treatment depth of 12", and recommendations from Julia Rockenstein at Caltrans, Condor mixed approximately 46% AC, 54% Base, with 2% cement (by weight) and determined the optimal percent foamed asphalt content for the mix. Based on the results of the testing, 2.5% PG 64-22 asphalt oil binder will be used for the project. The mix yielded an average dry strength of 62 psi and an average wet strength of 35 psi.

Condor's laboratory CFIPR mix design results are included in Appendix B.

5 CFIPR PAVEMENT SECTION RECOMMENDATIONS

Based on the existing pavement sections and Chapter 600 of the September 2006 Caltrans Highway Design Manual (CHDM), we recommend the treatment and pavement sections in Table 2.

Table 2: Recommendation Pavement Sections

Location (Station)	Hot Mix Asphalt (feet)	CFIPR (feet)
Station 92+00 to 224+50	0.35	1.0

Prior to pulverizing the CFIPR section, spread Portland Cement Type II at an approximate rate of 2.5 pounds per square foot. Following placement of Portland Cement, process 12 inches of the existing road with 2.5 percent PG 64-22 asphalt oil per the project specifications.

Due to the potential for the CFIPR section to increase vertically ½" to 2" during the process, grinding and removal may be required prior to placing the Hot Mix Asphalt (HMA) to maintain design grade.

Based on our engineering analysis and the CHDM the recommendations above will yield a rehabilitated roadway with a gravel equivalence ranging from 2.48 to 2.65. This meets Caltrans design criteria for a Traffic Index between 10.0 and 10.5.

The CFIPR specifications for the project (including pulverization, placement and compaction requirements) are included in Appendix C. Our pavement section calculations are included in Appendix D. A Caltrans Materials Handout is provided in Appendix E.

6 PAVEMENT MATERIALS

Hot Mix Asphalt (HMA-A) shall be Type A, ¾-inch maximum and conform to the provision of the May 2006 Caltrans Standard Specifications, Section 39.

Asphalt Binder shall be PG 64-22 without neat oil or polymers and conform to the provisions of the May 2006 Caltrans Standard Specifications, Section 92.

Portland Cement shall be Type II Portland Cement under and conform to ASTM C 150.

Open Graded Friction Course (OGFC) shall be 3/8-inch maximum and conform to the provision of the May 2006 Caltrans Standard Specifications, Section 39.

Prime Coat and Paint Binder (Tack Coat) shall conform to the provisions of the May 2006 Caltrans Standard Specifications, Sections 39-4.02 and 94.

7 LIMITATIONS

BCI performed services in accordance with generally accepted geotechnical engineering principles and practices currently used in this area. Where referenced, we used ASTM or Caltrans <u>standards</u> as a general (not strict) *guideline* only. We do not warranty our services.

BCI based this report on the current site conditions. We assumed the asphalt, base, and soil conditions encountered in our test pits are representative of the subsurface conditions across the site. Actual conditions between our test pits could be different.

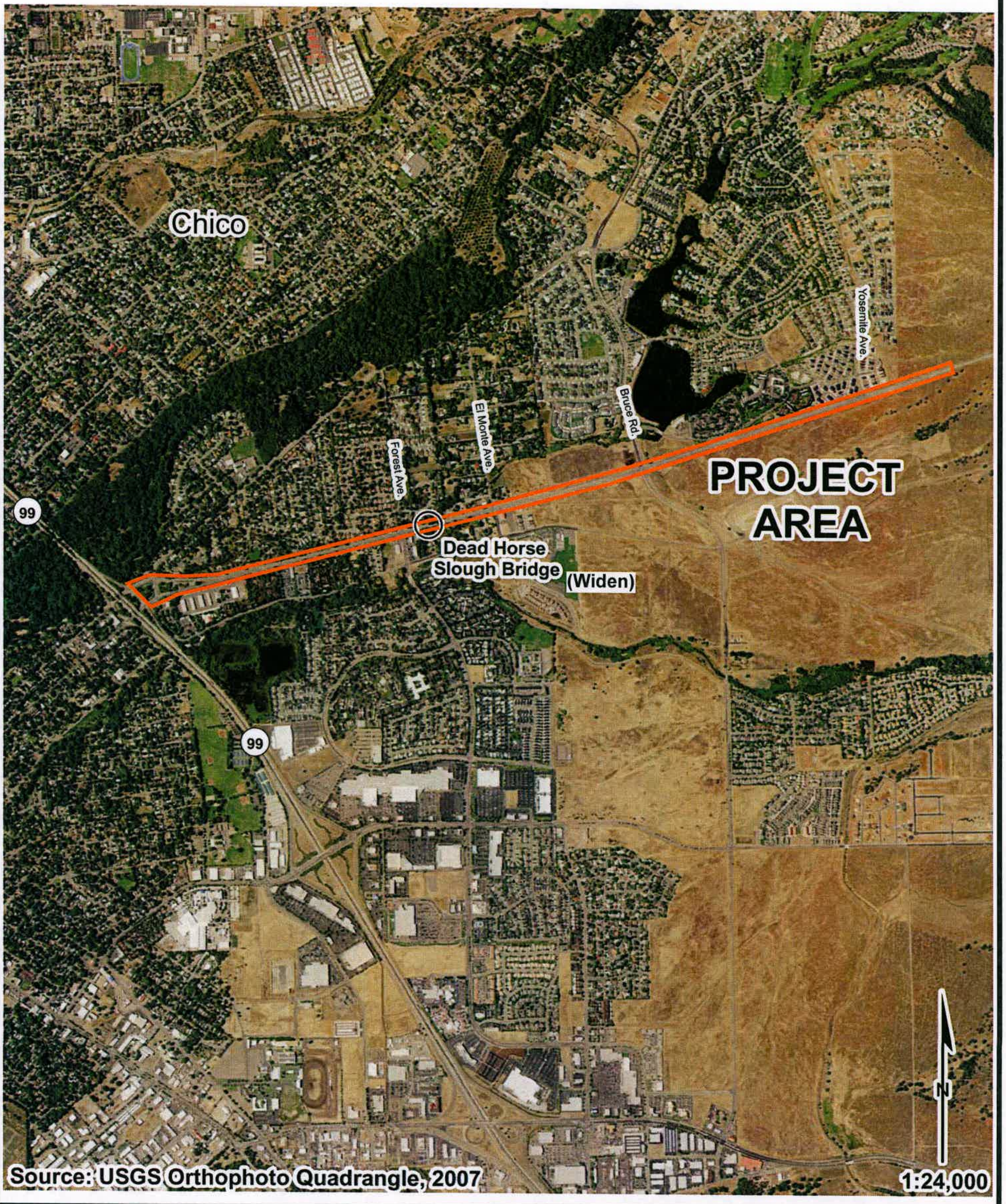
Our scope did not include evaluation of on-site hazardous material, flood potential, aerial photograph review, or biological pollutants. Please contact BCI if you would like an evaluation of one or more of these potentially damaging issues.

Modern design and construction issues are complex, with many regulatory sources/restrictions, involved parties, construction alternatives, etc. It is common to experience changes and delays. The owner should set aside a reasonable contingency fund based on complexities and cost estimates to cover changes and delays.

APPENDIX A

Figure 1: Vicinity Map

Figure 2: Site Plan



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VICINITY MAP

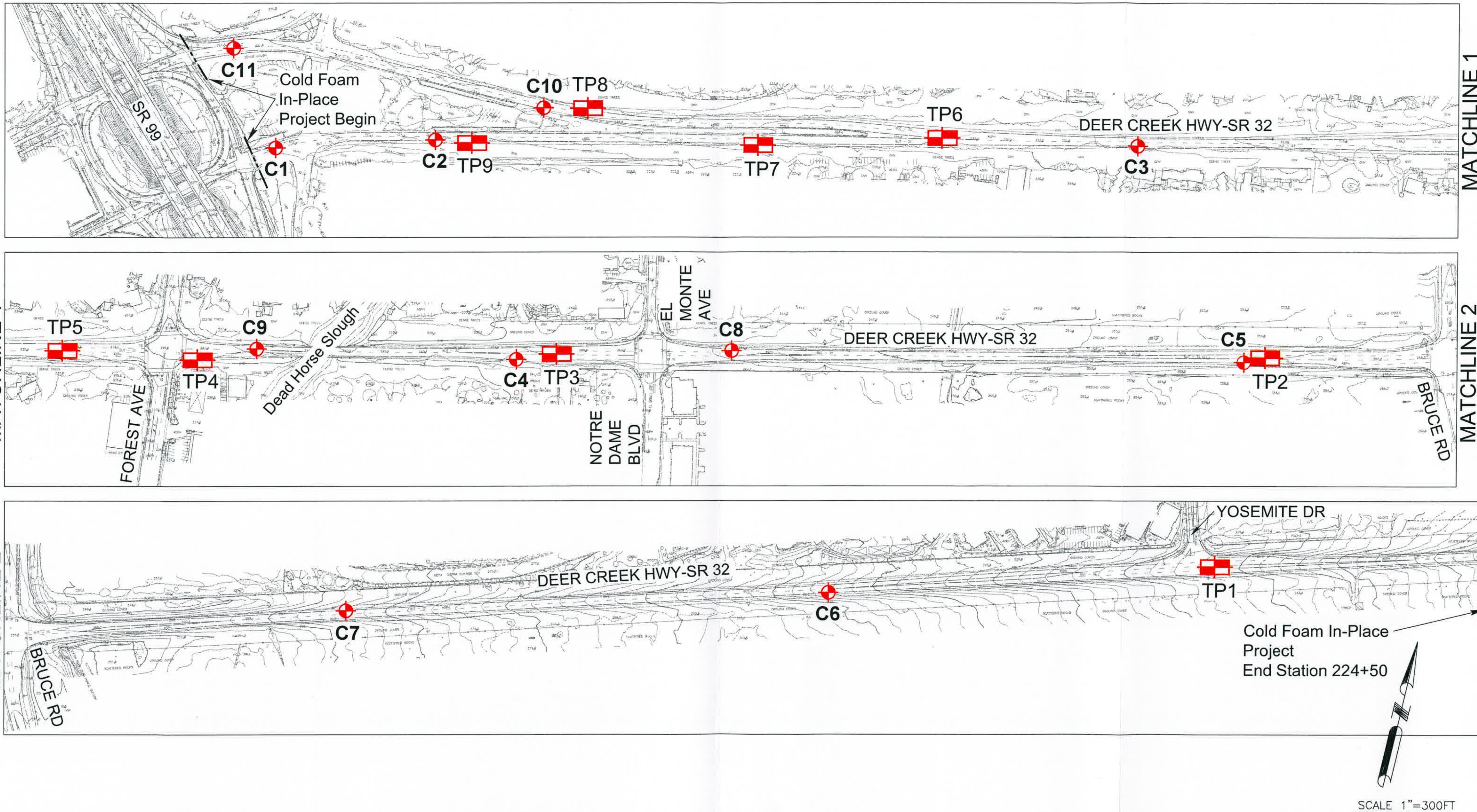
SR 32 Widening Project
Chico, California

File No. 1202.5

October 2010

Figure 1

11/1/2010 1202.5 SR 32 Widening GDR Figure 1.dwg



Source: Project map provided by Mark Thomas & Company.

LEGEND

TP1 — Approximate Test Pit Locations (BCI)

C1 — Approximate Pavement Core Location (CHEC)

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SITE PLAN AND COLD FOAM SAMPLING LOCATIONS

SR 32 Widening Project
Chico, California

File No. 1202.5

October 2010

Figure 2

APPENDIX B

Laboratory Test and

CFIPR Mix Results

blackburn consulting

Geotechnical ▪ Construction Services ▪ Forensics

CONDOR

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Stockton, CA 95206
Phone 209.234.0518
FAX 209.234.0538
www.condorearth.com

October 28, 2010

Ben Crawford
Blackburn Consulting
1720 G Street
Modesto, CA 95354

Subject: Results of Cold Foam Asphalt Mix Design
State Route 32 Widening Project
Butte County, California
Condor Project No. 5951

INTRODUCTION

Condor Earth Technologies, Inc. (Condor) is pleased to submit this letter report presenting the results of our laboratory cold foam asphalt (CFA) mix design for the State Route 32 Widening Project in Butte County, California. Condor's scope of services for the project included development of a CFA mix design using the anticipated proportions of existing asphaltic concrete (AC) and aggregate base (AB) materials.

COLD FOAM ASPHALT MIX DESIGN

Blackburn Consulting (Blackburn) collected samples of the existing asphaltic concrete (AC) and underlying aggregate base (AB) layer along the roadway within the project limits. The disturbed bulk samples of each component of the existing pavement section, including asphaltic concrete (AC) and aggregate base material (AB) collected by Blackburn were delivered to Condor's office in Stockton, California. In addition to the AC and AB samples, two 5-gallon buckets of PG 64-22 asphalt oil were delivered to our office by Blackburn. All samples (i.e., AC, AB, and oil) were transported from our Stockton office to our Jamestown laboratory for CFA mix design testing.

Based on our discussions with Ben Crawford of Blackburn, we understand that the thickness of the CFA pavement section design by Blackburn will be 12 inches. Based on the existing pavement section within the project limits, Mr. Crawford of Blackburn informed Condor that the proportion of AC and AB that would typically be encountered in foaming to a depth of 12 inches is 70% AC to 30%AB. The results of the grain size distribution test for the 70% AC to 30% AB blend indicate that the gradation of the in-place materials after pulverization did not fall within the recommended range for conventional design of CFA. Based on the gradation test, the pulverized material was too coarse ("rocky") and lacked the percentage of sand (filler) that would make this mix design desirable for foaming operations. Based on our discussions with Mr. Crawford of Blackburn, it was agreed that bedding sand would be added in order to improve the gradation of the material to be foamed for our initial CFA mix design. With the addition of the sand, the sand percentage in the mix design improved from 29.5 percent to 37.9 percent and the aggregate percentage decreased from 68.6 percent to 58.8 percent. Based on this increase in filler material, the new mix design gradation appeared to be more suitable for foaming operations.

The final proportioning of the initial CFA mix design was AC (57.5%), AB (30%), Bedding Sand (12.5%), and 2.0 percent Type II cement (by dry weight). The CFA mix design was performed with PG 64-22 asphalt oil contents ranging from 2.0 to 3.5 percent. Indirect tensile strength (ITS) tests were performed on both dry and soaked briquettes for the mix design. The laboratory tests and CFA mix design results are presented in Appendix A.

For the initial CFA mix design performed, the maximum ITS results for both dry and soaked samples were obtained with 2.5 percent PG 64-22 asphalt oil. Laboratory results indicate an average dry strength of 54 pounds per square inch (psi), an average soaked strength of 24 psi, and a tensile strength ratio based on the average values of 45 percent. The California Department of Transportation (Caltrans) typically recommends that the CFA have a minimum dry ITS of 45 psi, a minimum soaked ITS of 35 psi, and that the tensile strength retained be no less than 50 percent.

Since the average soaked strength and tensile strength retained for the initial CFA mix design did not achieve the minimum values of recommended by Caltrans, an additional CFA mix design was performed. Ms. Julia Rockenstein of Caltrans recommended to Blackburn that a new CFA mix design be performed on a blend having the proportions of 46% AC and 54% AB with 2 percent cement added. We are not aware of what CFA treatment depth would be required to achieve this blend. The results of the grain size distribution test for this additional mix design indicate that the gradation of the recommended proportions still did not fall within the recommended range for conventional design of CFA; however, the gradation appeared to be more suitable for foaming operations than the initial blend without the addition of sand filler. Similar to the initial CFA mix design, the additional CFA mix design was performed with PG 64-22 asphalt oil contents ranging from 2.0 to 3.5 percent. Indirect tensile strength (ITS) tests were performed on both dry and soaked briquettes for the mix design.

For the CFA mix design recommended by Caltrans, the maximum ITS results for both dry and soaked samples were obtained with 2.5 percent PG 64-22 asphalt oil. Laboratory results indicate an average dry strength of 62 pounds per square inch (psi), an average soaked strength of 35 psi, and a tensile strength ratio based on the average values of 57 percent.

CONCLUSIONS

Based on the CFA mix design results presented above, the optimum oil content to achieve the highest dry ITS was 2.5 percent by weight for both CFA mix designs performed. For both CFA mix designs, the addition of 2 percent Type II cement was used to improve the strength of the foamed materials. Based on the ITS results, the CFA mix design recommended by Caltrans with the proportions of 46% AC and 54% AB achieved the minimum values recommended by Caltrans for dry strength, soaked strength, and retained strength. The cement spread rate and oil application rate should be based on the average dry unit weight of 130 pounds per cubic feet which was obtained on the test specimens from the ITS tests for the Caltrans recommended CFA mix design. A test strip is strongly recommended to verify field performance of the mix design.

LIMITATIONS

Condor has provided the CFA pavement design parameters in accordance with our contract between Condor and Blackburn, and our proposal dated May 21, 2010. The results of our CFA mix designs presented in this letter report are intended for planning and construction activities for the proposed State Route 32 Widening Project in Butte County, California. These results may be invalid if:

- the design assumptions change;
- the letter report is used for another site or project;
- the encountered pavement conditions result in proportions of AC and AB that are different than those tested in our mix designs; or
- any other change is implemented that materially alters the proportions of AC and AB tested in our mix designs.

This letter report was prepared in accordance with the generally accepted standards of laboratory testing of CFA materials at the time this report was written. No other warranty, expressed or implied, is made. It is the owner's responsibility to see that all parties to the project, including the designer, contractors, subcontractors, etc., are made aware of this letter report in its entirety.

The conclusions submitted herein are based upon the samples obtained and mix design proportions provided to Condor by Blackburn. Should the proportions of AC and AB encountered during foaming operations differ from those tested in our mix designs, additional laboratory testing or analysis may be required.

The recommendations of this report assume that the appropriate project specifications are prepared by Blackburn and are adhered to during construction, and that a test section is performed to verify field performance of the mix design. It should also be noted that changes in the standards of practice in the field of geotechnical engineering, changes in site conditions, new agency regulations, or modifications to the proposed project are grounds for this letter report to be professionally reviewed. In light of this, there is a practical limit to the usefulness of this letter report without critical professional review. It is suggested that one year be considered a reasonable time for the usefulness of this letter report.

Respectfully submitted,

CONDOR EARTH TECHNOLOGIES, INC.

REGISTERED PROFESSIONAL ENGINEER
ANTHONY P. MAZZEI
2823
EXP. 6/30/11
GEOTECHNICAL
STATE OF CALIFORNIA

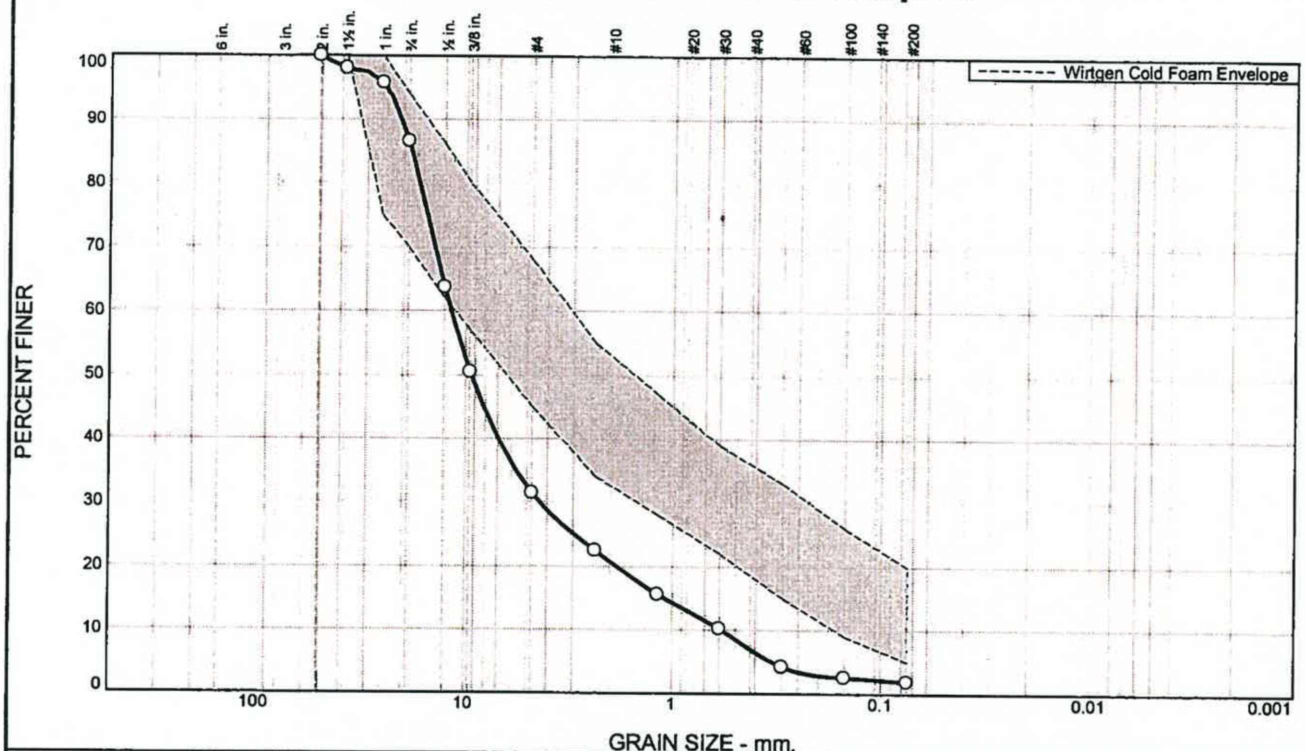
Anthony P. Mazzei
Geotechnical Engineer (CA# 2823)
Engineering Services Manager

Attachments: Appendix A – Laboratory Test Results

P:\5000_prj\5951 Chico Cold Foam Project\Reports\R 20101028 CFA Mix Design.doc

APPENDIX A
Laboratory Test Results

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	13.5	55.1	10.7	13.7	5.1	1.9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2.0	100.0	100.0 - 100.0	
1.5	98.0	100.0 - 100.0	X
1.0	95.8	75.0 - 100.0	
.75	86.5	70.0 - 94.0	
.5	63.7	62.0 - 86.0	
.375	50.5	57.0 - 80.0	X
#4	31.4	45.0 - 68.0	X
#8	22.4	34.0 - 55.0	X
#16	15.6	28.0 - 47.0	X
#30	10.2	22.0 - 39.0	X
#50	4.2	15.0 - 33.0	X
#100	2.5	9.0 - 26.0	X
#200	1.9	5.0 - 20.0	X

* Wirtgen Cold Foam Envelope

Material Description

70% Asphalt, 30% Aggregate Base

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 18.4533 D_{60}= 11.8305 D_{50}= 9.4071
D_{30}= 4.3713 D_{15}= 1.1007 D_{10}= 0.5856
C_u= 20.20 C_c= 2.76

Classification

USCS= GW AASHTO=

Remarks

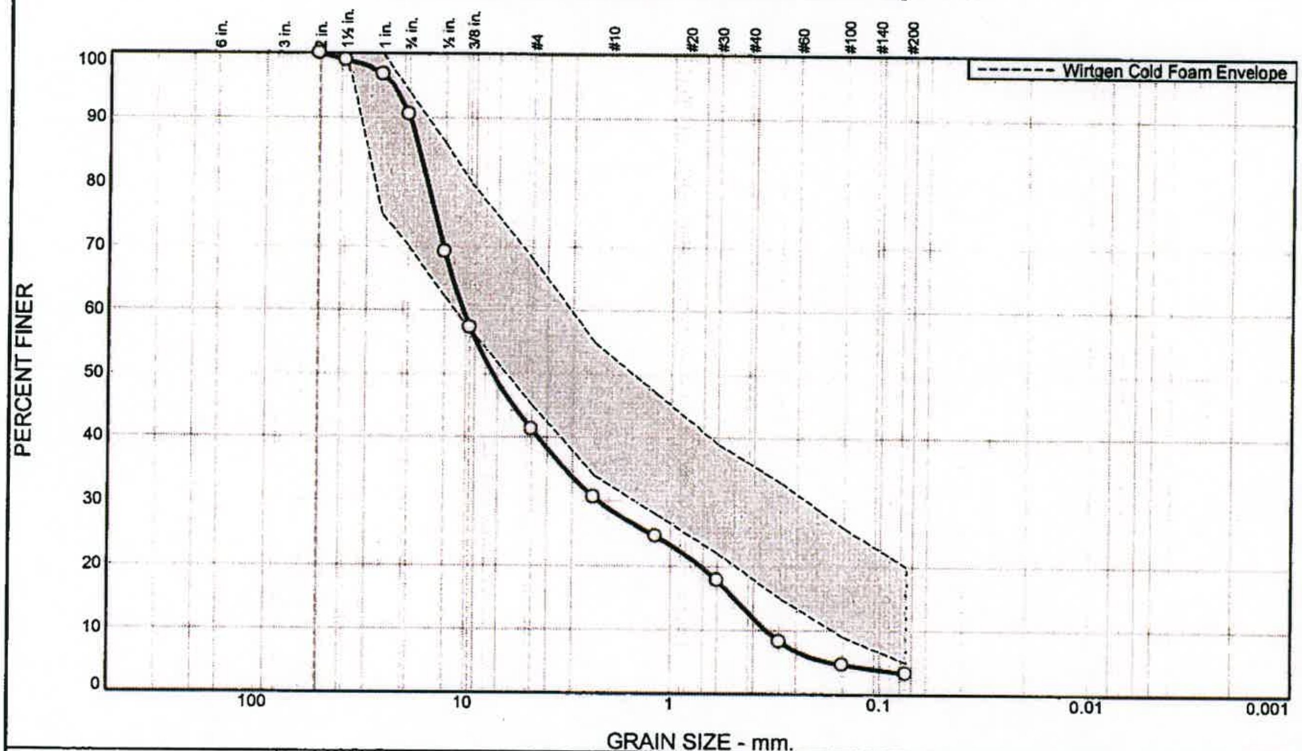
Sample Number: SA-1
Location: Comosite Sample

Date: 9/16/2010

CONDOR EARTH TECHNOLOGIES Jamestown, CA	**Client:** Blackburn Consulting **Project:** State Route 32 Widening Project **Project No:** 5951 **Figure**

Tested By: Anthony Allopenna **Checked By:** Tony Mazzei

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	9.5	49.3	12.3	16.1	9.5	3.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2.0	100.0	100.0 - 100.0	
1.5	99.0	100.0 - 100.0	X
1.0	96.8	75.0 - 100.0	
.75	90.5	70.0 - 94.0	
.5	69.1	62.0 - 86.0	
.375	57.3	57.0 - 80.0	
#4	41.2	45.0 - 68.0	X
#8	30.6	34.0 - 55.0	X
#16	24.6	28.0 - 47.0	X
#30	17.8	22.0 - 39.0	X
#50	8.3	15.0 - 33.0	X
#100	4.7	9.0 - 26.0	X
#200	3.3	5.0 - 20.0	X

* Wirtgen Cold Foam Envelope

Material Description

12.5% Sand, 30.0% AB, 57.5% AC

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 16.8846 D_{60}= 10.2993 D_{50}= 7.3756
D_{30}= 2.2340 D_{15}= 0.4921 D_{10}= 0.3473
C_u= 29.66 C_c= 1.40

Classification

USCS= GW AASHTO=

Remarks

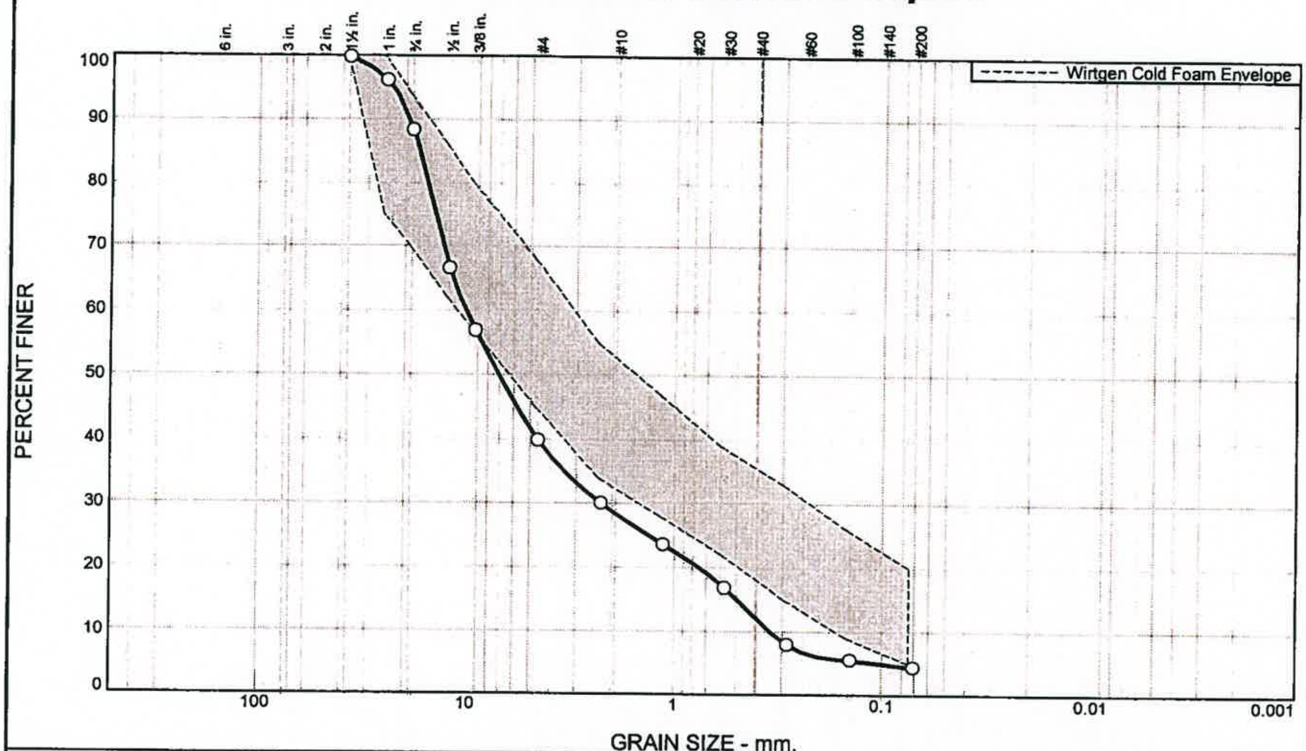
Sample Number: SA-2
Location: Composite Sample

Date: 9/23/2010

CONDOR EARTH TECHNOLOGIES Jamestown, CA	**Client:** Blackburn Consulting **Project:** State Route 32 Widening Project **Project No:** 5951 **Figure**

Tested By: Anthony Allopenna **Checked By:** Tony Mazzei

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	11.5	48.2	11.4	16.2	7.7	5.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0	100.0 - 100.0	
1.0	96.3	75.0 - 100.0	
.75	88.5	70.0 - 94.0	
.5	66.8	62.0 - 86.0	
.375	57.2	57.0 - 80.0	
#4	40.3	45.0 - 68.0	X
#8	30.6	34.0 - 55.0	X
#16	24.1	28.0 - 47.0	X
#30	17.4	22.0 - 39.0	X
#50	8.6	15.0 - 33.0	X
#100	6.2	9.0 - 26.0	X
#200	5.0	5.0 - 20.0	

* Wirtgen Cold Foam Envelope

Material Description

46% AC, 54% AB, 2% Cement

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 17.6825 D_{60}= 10.5228 D_{50}= 7.2653
D_{30}= 2.2353 D_{15}= 0.5020 D_{10}= 0.3449
C_u= 30.51 C_c= 1.38

Classification

USCS= AASHTO=

Remarks

Sample Number: SA-4
Location: Composite Sample

Date: 10-5-2010

CONDOR EARTH TECHNOLOGIES
Jamestown, CA

Client: Blackburn Consulting
Project: State Route 32 Widening Project
Project No: 5951 **Figure**

Tested By: A. Allopenna **Checked By:** A. Mazzei

FOAM MIX DESIGN REPORT

Client: Blackburn Consultanting
Project : State Route 32 Widening Project

Sample Number : CFA Mix 1

Material to be foamed

Location :	Composite
Material Description:	12.5% Sand, 30% AB, 57.5% AC
Optimum moisture content :	
Maximum dry density :	

Asphalt cement used for foaming

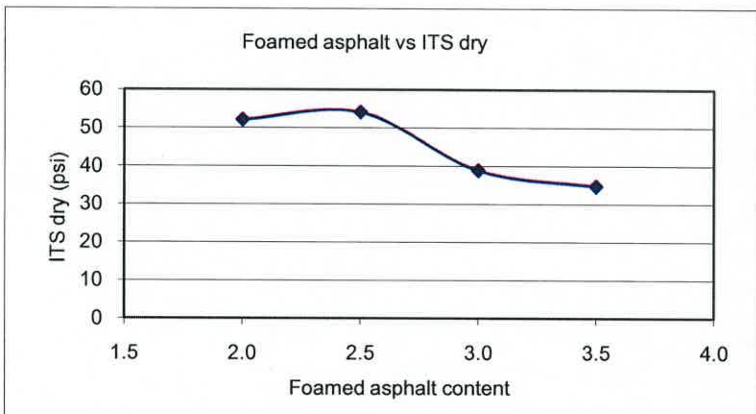
Supplier :	KENT'S OIL SERVICE
Type:	PG 64-22

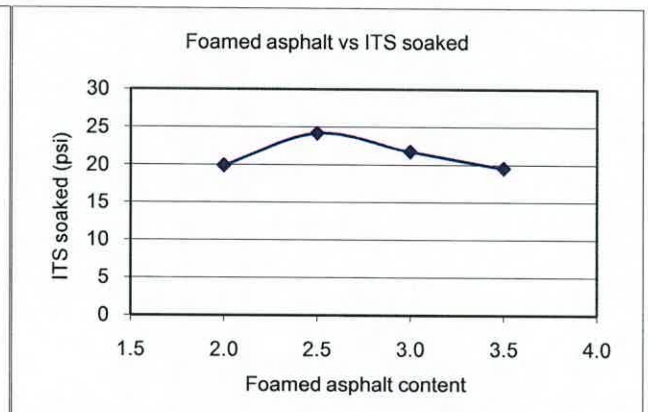
Foam requirements

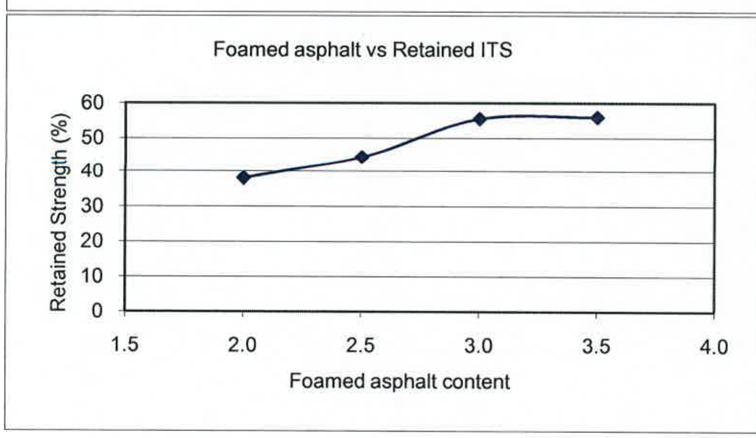
Percentage "foaming" water :	3
Temperature of asphalt cement :	180oC
Type II Cement	2%

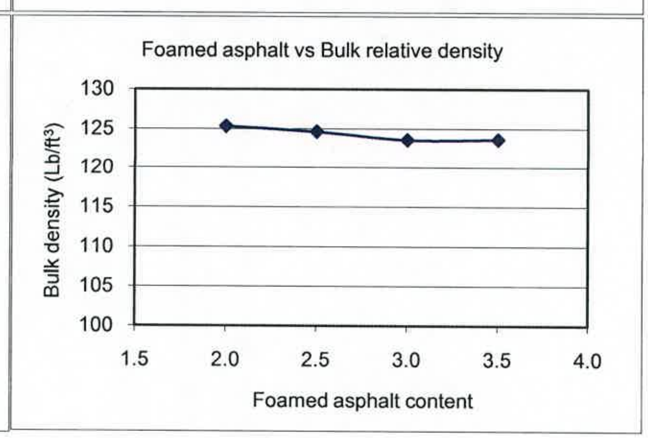
Foamed asphalt treated material characteristics

Foamed asphalt added (%) :	2.0	2.5	3.0	3.5
Diameter of specimen (in)	4.0	4.0	4.0	4.0
Height of specimen (in) :	2.6	2.6	2.7	2.6
Mass of specimen (lb) :	2.4	2.4	2.4	2.4
Bulk density (pcf):	125	125	124	124
ITS dry (psi):	52	54	39	35
ITS soaked (psi):	20	24	22	20
Retained ITS (%):	38	45	56	56









FOAM MIX DESIGN REPORT

Client: Blackburn Consultanting
Project : State Route 32 Widening Project

Sample Number : CFA Mix 2

Material to be foamed

Location :	Composite
Material Description:	54% AB, 46% AC
Optimum moisture content :	
Maximum dry density :	

Asphalt cement used for foaming

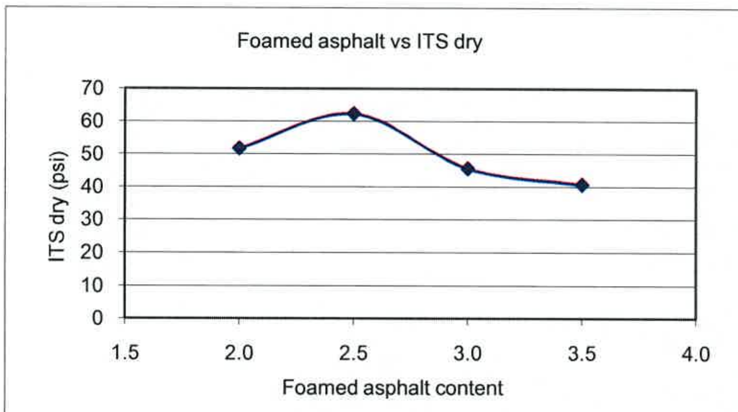
Supplier :	KENT'S OIL SERVICE
Type:	PG 64-22

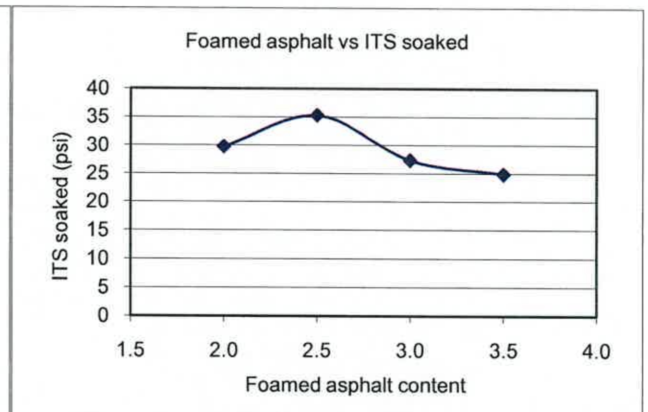
Foam requirements

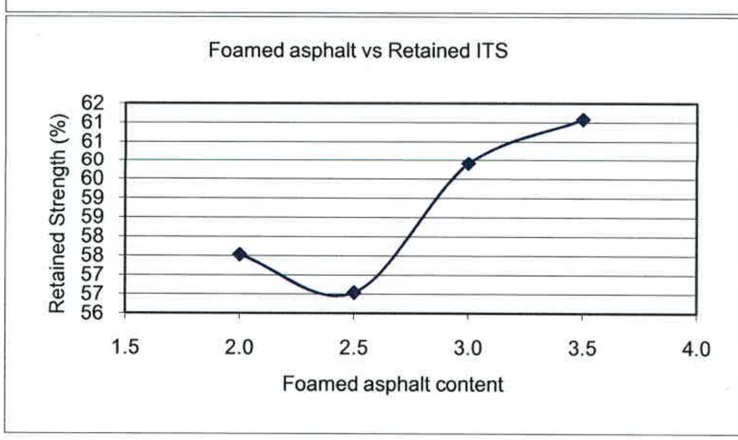
Percentage "foaming" water :	3
Temperature of asphalt cement :	180oC
Type II Cement	2%

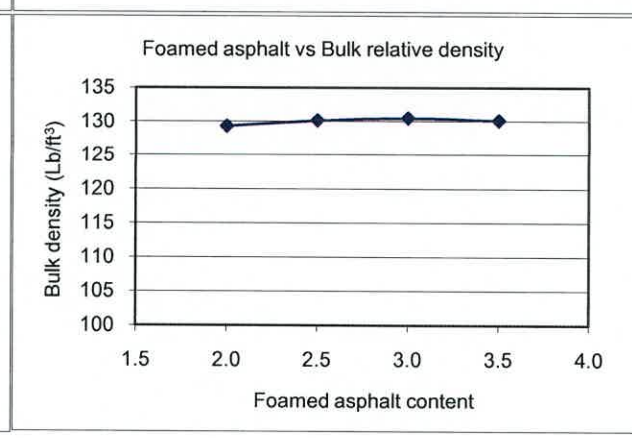
Foamed asphalt treated material characteristics

Foamed asphalt added (%) :	2.0	2.5	3.0	3.5
Diameter of specimen (in)	4.0	4.0	4.0	4.0
Height of specimen (in) :	2.6	2.6	2.6	2.5
Mass of specimen (lb) :	2.4	2.4	2.4	2.4
Bulk density (pcf):	129	130	130	130
ITS dry (psi):	52	62	46	41
ITS soaked (psi):	30	35	27	25
Retained ITS (%):	58	57	60	61









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Project Name: SR 132 Widening (Cold Foam)
Project No: 1202.5
Report Date: August 31, 2010
Sample No: TP-5 / Bag B
Sample Description: 1 1/2" Aggregate Subbase
Source: Test Pits

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (CTM 202)

Sieve	Sieve Size	"As Received" Grading (%)	Operating Range*	Contract Compliance**
3.0 inch	75 mm			
2 1/2 inch	62.5 mm			
2.0 inch	50 mm	100		
1.5 inch	37.5 mm	99		
1.0 inch	25.0 mm	89		
3/4" inch	19.0 mm	81		
1/2 inch	12.5 mm	69		
3/8" inch	9.5 mm	62		
No. 4	4.75 mm	51		
No. 8	2.36 mm	44		
No.16	1.18 mm	38		
No. 30	600 µm	28		
No. 50	300 µm	17		
No. 100	150 µm	8		
No. 200	75 µm	6		

SAND EQUIVALENT TEST (CTM 217)

Trial No.	1	2	3		
SAND	3.1	3.1	3.0		
CLAY	6.3	6.2	5.8	**Operating Range***	**Contract Compliance****
S.E.	**50**	**50**	**52**		
S.E. Avg.	**51**				
Tested By:	M. D. Leming		Date:	8/31/10	

* Operating Range for Class 2 Aggregate Base (3/4" Maximum)

** Contract Compliance for Class 2 Aggregate Base (3/4" Maximum)

Reviewed by:
Benjamin D. Crawford, PE, GE

Lab Certifications
Caltrans 248
CCRL 2342
AMRL 4122

AASHTO R18

APPENDIX C

SR 32 CFIPR Specifications

SR 32 COLD IN-PLACE RECYCLED ASPHALT SPECIFICATIONS

1 GENERAL

2 Summary

This work includes constructing a homogeneous stabilized base of cold foam in-place recycling (CFIPR) by milling existing asphalt concrete and existing underlying materials, mixing with water and stabilizing agent, and shaping and compacting the mixture.

3 Definitions

Stabilizing agent: Foamed asphalt binder used with cementitious material and mixed with milled asphalt concrete, existing underlying materials, and water to form a stabilized base.

4 Submittals

4.1 Test Strip

For the test strip, submit a written report within 24 hours of obtaining results that includes:

1. Test results
2. Asphalt binder temperature
3. Stabilizing agent:
    a. Ingredients
    b. Application rate
    c. Quantity
    d. Expansion ratio (maximum volume divided by original volume)
    e. Half-life in seconds
4. Water application rate and quantity
5. Moisture content of:
    a. Existing pavement
    b. Compacted CFIPR
6. In-place density of compacted CFIPR
7. Relative compaction of compacted CFIPR
8. Dilution rate of asphaltic emulsion
9. Recorded depth of cut measurements

4.2 Just-In-Time-Training

At least 7 days before Just-In-Time-Training (JITT), submit copies of:

1. Syllabus
2. Handouts
3. Presentation material

Submit the JITT instructor's:

1. Name
2. Address
3. Phone number
4. State engineering registration number

4.3 Production

For each day you work on CFIPR, submit within 24 hours of obtaining results:

1. Recorded depth of cut measurements
2. Stabilizing agent:
   a. Temperature
   b. Application rate and quantity
   c. Expansion Ratio (maximum volume divided by original volume)
   d. Half-life in seconds
3. Water application rate and quantity
4. CFIPR gradation
5. Moisture content of compacted CFIPR
6. In-place density of compacted CFIPR
7. Relative compaction of compacted CFIPR
8. Tensile strength test results from the previous day's work
9. Core data including:
   a. Thickness
   b. Sublot
   c. Location by station or post mile
   d. Offset

4.4 Asphaltic Emulsion

With each dilution of asphaltic emulsion, submit in writing:

1. Weight ratio of water to bituminous material in the original asphaltic emulsion
2. Weight of asphaltic emulsion before diluting
3. Weight of added water
4. Final dilution weight ratio of water to asphaltic emulsion

5 Quality Control and Assurance

The asphalt meter must comply with the specifications for metering devices in Section 9-1.01, "Measurement of Quantities," of the Standard Specifications. Calibrate the asphalt meter in the presence of the Engineer. The Engineer determines the frequency of testing and calibration. Perform California Test 109 on the asphalt meter before starting CFIPR work.

5.1 Just-In-Time Training

Your personnel must complete JITT. JITT is a formal training class for CFIPR work by an instructor you provide.

JITT must be:

1. At least 2 hours long
2. Conducted within 3 miles of the job site
3. Completed within 5 business days before you start pulverizing the roadbed
4. Conducted during normal working hours

The following staff must complete JITT:

5. Project manager
6. Project superintendent
7. Quality control staff
8. Equipment operators

The JITT instructor must be experienced with CFIPR methods, materials, and tests. The instructor must be neither your employee nor a Department field staff member. The instructor must be registered as an engineer in the State. Upon completion of JITT, the instructor must issue a certificate of completion to the participants.

The Engineer may waive training for personnel who have completed equivalent training within the 12 months preceding JITT. Submit each certificate of completion for the equivalent training.

5.2 Test Strip

On the first day of CFIPR activities and within the limits of the CFIPR, construct a test strip of CFIPR to the specified depth for a single lane width at least 1,000 feet long. Use the same equipment, materials, and construction methods for the test strip as the rest of the CFIPR.

The test strip must determine that:

1. Equipment, materials, and processes produce CFIPR in compliance with the specifications
2. Effect of varying the reclaiming machine's forward speed and drum rotation rate on the consistency of the recycled material
3. Optimal proportions of stabilizing agent, and water
4. Rolling method and sequence to comply with the compaction specifications
5. Dilution rate of asphaltic emulsion

Measure asphalt binder temperature for the test strip at the truck's tank for each load delivered to the job site.

Test the test strip for:

1. Moisture content
2. Gradation
3. Relative compaction

If the test strip does not comply with the specifications, stop CFIPR activities. Reprocess, recompact, or remove and replace the test strip until it complies with the specifications. Do not resume CFIPR activities until you inform the Engineer of the adjustments you will make. Construct a new test strip.

After approval of a test strip, if CFIPR does not comply with the compaction specifications, stop CFIPR activities and construct a new test strip.

5.3 Quality Control Inspection, Sampling, and Testing

Establish, maintain, and update a quality control system that includes inspection, sampling, and testing. Meet with the Engineer 1 week before starting CFIPR activities to review the quality control system.

Take samples under California Test 125. Give the Engineer unrestricted access to sampling and testing.

Furnish a testing laboratory with testing personnel for quality control that has been qualified under the Department's Independent Assurance Program.

Perform moisture content tests of existing asphalt concrete and underlying materials under California Test 226 not more than 7 days in advance of CFIPR activities. Take a minimum of four samples per project. Submit sample locations to the Engineer for approval not less than 3 days prior to sampling.

Take a 1-quart asphalt binder sample and record the temperature for each load delivered to the job site.

Test a 3-pound sample of CFIPR material for gradation under California Test 202 for every 1,000 square yards of CFIPR. Before compaction, take samples 3 feet from either longitudinal edge of the CFIPR section. If the test results do not comply with the specifications, stop CFIPR activities and inform the Engineer. Before resuming CFIPR activities, reprocess the noncompliant CFIPR material until it complies with gradation specifications.

Daily, take 6 samples of uncompacted CFIPR material that are each 0.5' x 0.5' in area and to the specified depth. Evenly space the samples across the CFIPR section's full width. Perform a sieve analysis on each sample under California Test 202 and discard the material retained on the 1-inch sieve. From the material passing the 1-inch sieve, make 6 sample briquettes under California Test 304, Part 2. Cure the briquettes at 100 °F for 72 hours. After curing, allow the briquettes to cool to room temperature. Test 3 briquettes for tensile strength at room temperature under California Test 371. Test the remaining 3 briquettes for tensile strength under California Test 371 after soaking in water for 24 hours. The minimum dry/wet tensile strength will be 75% of the average tensile strengths given in the Materials Handout.

Measure and record the actual cut depth at both ends of the milling drum at least once every 300 feet along the cut length. Take measurements in the Engineer's presence.

Determine the in-place density and relative compaction of the finished CFIPR layer for every 1,000 square yards of CFIPR. Determine the relative compaction under California Test 231 modified as follows:

1. Take nuclear gauge counts at 3 elevations within the CFIPR layer. These elevations are identified as E1, E2, and E3. The elevations are:
    a. E1 = 1/3 x (CFIPR thickness - 1 inch)
    b. E2 = 2/3 x (CFIPR thickness - 1 inch)
    c. E3 = (CFIPR thickness - 1 inch)
2. Correction for oversize material does not apply
3. A sample must contain no more than 5 percent retained on the 1-inch sieve and 10 percent retained on the 3/4-inch sieve

Measure the moisture content of the compacted CFIPR material under California Test 226 each time you take a compaction test.

If the test results do not comply with the specifications, stop CFIPR activities and inform the Engineer. Before resuming activities:

1. Inform the Engineer of the adjustments you will make
2. Update the quality control system
3. Construct a test strip demonstrating ability to comply with the compaction specifications
4. Reprocess the noncompliant material until it complies with compaction specifications

6 MATERIALS

6.1 Aggregate Base

Aggregate base must comply with "Aggregate Base." Use the 3/4-inch maximum grading. Aggregate base must not include cinders. Do not use aggregate base with more than 50 percent by volume of reclaimed asphalt pavement. Aggregate base must weigh at least 105 pounds per cubic foot, determined under California Test 212, Compacted Method (by Rodding).

6.2 Asphalt Binder

Asphalt binder used in the stabilizing agent must comply with Section 92, "Asphalts," of the Standard Specifications. The grade of asphalt binder must be PG 64-22. Do not heat asphalt binder above 375 °F.

6.3 Cementitious Material

In the stabilizing agent, add 2 percent cementitious material by dry weight of CFIPR material. Cementitious material must be Type II portland cement under ASTM C 150.

6.4 Water

Water for CFIPR must be clean and contain no more than 650 parts per million of chlorides as Cl, and no more than 1,300 parts per million of sulfates as S04.

6.5 Asphaltic Emulsion

Asphaltic emulsion must comply with Section 94, "Asphaltic Emulsions," of the Standard Specifications. The grade of asphaltic emulsion must be SS1h or CSS1h. For dilution, the weight ratio of added water to asphaltic emulsion must not exceed 1 to 1.

6.6 Rapid Strength Concrete

Rapid strength concrete must be one of the following, or equal:

1. Set 45
2. Burke Fast Set
3. Ceratech DOT
4. Ceratech SL

7 CONSTRUCTION

7.1 General

Do not start CFIPR activities if the National Weather Service forecasts rain at the job site within 24 hours. Do not start CFIPR activities if the ambient air temperature is below 50 °F or the road surface is below 50 °F. If the ambient air temperature is below 50 °F, you may only finish and compact CFIPR.

Before starting each day's CFIPR activities, sweep the CFIPR area you constructed the previous day to remove loose material.

7.2 Equipment

CFIPR equipment for water and stabilizing agent must be independent, interlocked, and each must include the following:

1. Digital electronic controller system
2. Pumping system
3. Spray bar system

Operating in relation to the equipment's forward speed and the weight of material being recycled, the controller, pumping, and spray bar systems must regulate stabilizing agent and moisture content of the milled pavement and underlying material. The rate by weight of water added to make stabilizing agent must be controlled with the same controller.

Spray bars must be fitted with self-cleaning nozzles or nozzles that indicate flow. Space the nozzles evenly at a rate of 1 nozzle for every 6 to 8 inches of mixing chamber width.

Apply the stabilizing agent atomized under pressure through individual and separate small orifices.

Fit an inspection nozzle at 1 end of the stabilizing agent spray bar. The inspection nozzle must produce a representative sample of stabilizing agent.

Use a heating system to maintain the temperature of asphalt binder above 340 °F including when the asphalt binder is injected. Use a thermometer in the asphalt binder feed line to the CFIPR machine before introduction of water to the asphalt binder to measure asphalt binder temperature.

Use a mass flow, coriolis effect type asphalt meter. The meter must have a controller, a visible readout display, and printing capabilities.

The distance from the stabilizing agent spray nozzle to the top of the cutter tooth holder must be at least the depth of cut.

Mobile asphalt binder storage equipment must:

1. Attach to the CFIPR machine
2. Not leak
3. Have a sampling valve

Do not service CFIPR equipment on the travelled way.

Spreading equipment must be mechanical. Spreading equipment may be any of the following:

1. Screed mounted on the rear of the mixing equipment
2. Mixing equipment
3. Motor grader

Compacting equipment must consist of 1 vibratory sheepsfoot roller with a blade for each CFIPR machine, a vibratory steel drum roller, and a pneumatic-tired roller. Compacting equipment must be self-propelled and reversible. The frequency and amplitude of vibrating rollers must be adjustable and exceed a static weight of 15 tons in vibratory mode.

7.3 Surface Preparation

Before CFIPR activities start, prepare the existing roadway surface by:

1. Clearing foreign matter including vegetation
2. Removing standing water
3. Referencing the profile and cross slope
4. Marking the proposed longitudinal cut lines on the existing pavement as follows:
    a. Cut lines must coincide with points where the existing cross slope changes, approximately at the centerline and edge of traveled way
    b. Cut lines must indicate the sequence of the cuts

7.4 Spreading Materials

Spread cementitious material immediately before the operation that blends the milled material with stabilizing agent. Spread dried cementitious material uniformly over the full width. The spread rate must be 2.5 lbs per square foot. Do not spread cementitious materials in windy conditions.
Inform the Engineer if adjustments to the stabilizing agent injection rate are necessary.

Do not apply water to an uncompacted surface.

7.5 Milling and Mixing

If you encounter unsuitable material under Section 19-2.02, "Unsuitable Material," of the Standard Specifications, remove subgrade to at least 2 feet below milling depth. Replace unsuitable material with Class 2 aggregate base under Section 26, "Aggregate Base," of the Standard Specifications to the level of the existing pavement surface.

The CFIPR equipment's forward speed must not exceed 6 yards per minute. Set the speed so that, when combined with the other adjustable components, the specified depth is milled in 1 pass. Do not pulverize asphalt concrete before CFIPR activities.

The mixture of milled material, base, and cementitious material must comply with the following grading:

CFIPR Gradation

Sieve Size	Percentage Passing
4"	100
3"	95 - 100
1.5"	85 - 100

The first cut width must equal the width of the milling drum and subsequent cut widths must be less than the drum width by at least 2 inches. If a cut deviates more than 2 inches inside the cut line, immediately reverse to where the deviation began and mill along the correct line without any further water or stabilizing agent. If a cut deviates more than 2 inches outside the cut line, immediately adjust. With each cut, adjust the amount of water and stabilizing agent proportionally to the actual cut width.

Do not leave a gap of unmilled material between cuts. Do not leave a wedge at the entry of the milling drum into the existing material.

Mark the existing pavement where each cut will terminate. Position the mark to where the milling drum's center will be when the milling stops. Start the following cut on this alignment at least 2 feet behind this mark.

The maximum time period between mixing the milled material with stabilizing agent and compacting the CFIPR is 3 hours.

7.6 Compaction

Compact immediately after spreading CFIPR.

During compaction, the moisture content determined under California Test 216 must be from 2 percent below the optimum moisture content to the optimum moisture content.
Compact CFIPR to a relative compaction of at least 98 percent before opening to traffic.

The profile and cross slope of the compacted CFIPR must be within 0.05 foot of the grade shown on the plans.

After compaction, apply water and roll with pneumatic-tired rollers. The final surface must be free of ruts, bumps, indentations, and segregation.

Keep the compacted surface damp by lightly watering the surface 4 times per day for 4 days after compacting.

Apply a coat of diluted asphaltic emulsion to the finished surface. The residual application rate of asphaltic emulsion must be from 0.13 to 0.25 gallons per square yard. The dilution must be 50 percent water and 50 percent asphaltic emulsion. Do not apply asphaltic emulsion until the moisture content is 2 percent below the optimum moisture content at mid-depth determined under California Test 216 and California Test 231. Do not apply water to applied asphaltic emulsion.

Before placing HMA, take cores to determine the finished compacted CFIPR thickness. Record each core's measurements in the Engineer's presence. Each core's record must include the location, sublot, and station or postmile. Take 1 core every 1,000 square yards except at day's end. At day's end, if the quantity of CFIPR since the last core is from 500 to 1,000 square yards, take a core to represent this quantity. If the quantity is less than 500 square yards, this quantity is represented by the previous core. Fill core holes with rapid strength concrete.

If a core is more than 0.05 foot less than the specified thickness, core at intermediate sites to determine the extent of the deficient thickness. Remove the CFIPR material deficient in thickness by cold planing to a depth of 0.2 foot below the finished CFIPR grade. Replace the planed CFIPR with the hot mix asphalt specified for the project and compact thoroughly.

Sweep the entire surface and install construction area traffic control devices.

Do not open to traffic without the Engineer's approval.

Protect and maintain CFIPR until you place hot mix asphalt. After applying asphaltic emulsion, keep the surface dry. Repair damaged CFIPR material with hot mix asphalt.

8 MEASUREMENT AND PAYMENT

Cold foam in-place recycling including test strips is measured by the square yard. The Engineer measures the area for payment using the in-place length and width of CFIPR.

Stabilizing agent (foamed asphalt) is measured by the ton as specified for asphalt under Section 92-1.04, "Measurement," of the Standard Specifications.

Stabilizing agent (cementitious material) is measured by the ton.

Aggregate base is measured and paid as specified under Section 26, "Aggregate Bases," of the Standard Specifications.

Asphaltic emulsion is measured under Section 94, "Asphaltic Emulsions," of the Standard Specifications. Measure dilution water either by weight or volume in compliance with the specifications for weighing, measuring, and metering devices under Section 9-1.01, "Measurement of Quantities," or you may use water meters from water districts, cities, or counties. If you measure water by volume, apply a conversion factor to determine the correct weight.

The contract price paid per square yard for cold foam in-place recycling includes full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in cold foam in-place recycling including coring, complete in place, as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

The contract price paid per ton for stabilizing agent (foamed asphalt) includes full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in stabilizing agent (foamed asphalt), complete in place, as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

The contract price paid per ton for stabilizing agent (cementitious material) includes full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in stabilizing agent (cementitious material), complete in place, as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

The contract price paid per ton for asphaltic emulsion shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in asphaltic emuslsion, complete in place, including water for dilution, as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

Costs for providing JITT are determined under Section 9-1.03, "Force Account Payment," of the Standard Specifications, except no markups are added. You are paid 1/2 of the JITT costs. JITT costs include training materials, class site, and the JITT instructor including the JITT instructor's travel, lodging, meals and presentation materials. The costs for personnel attending JITT are paid by the party incurring the costs.

APPENDIX D

CFIPR Pavement Section Calculations

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Cold Foam Asphalt Calculations

Existing Pavement Section = 18" (AC + AB)

4" HMA, 12" CFA, and 6" ASB (existing AB meets Caltrans ASB)

GE_{Total} = AC Thickness x G_{F-AC} + CFA Thickness x G_{F-CFA} + ASB Thickness x G_{F-ASB}

GE_{Total} = 0.33' AC(1.75) + 1.0' CFA(1.4) + 0.5' ASB(1.0) = 2.48

Existing Pavement Section = 20" (AC + AB)

4" HMA, 12" CFA, and 8" ASB (existing AB meets Caltrans ASB)

GE_{Total} = AC Thickness x G_{F-AC} + CFA Thickness x G_{F-CFA} + ASB Thickness x G_{F-ASB}

GE_{Total} = 0.33' AC(1.75) + 1.0' CFA(1.4) + 0.67' ASB(1.0) = 2.65

East of Dead Horse Slough and West of Norte Dame Blvd

Existing Pavement Section = 32" (AC + AB)

2" HMA, 12" CFA, and 20" ASB (existing AB meets Caltrans ASB)

GE_{Total} = AC Thickness x G_{F-AC} + CFA Thickness x G_{F-CFA} + ASB Thickness x G_{F-ASB}

GE_{Total} = 0.17' AC(1.75) + 1.0' CFA(1.4) + 1.67' ASB(1.0) = 3.37

Required Pavement Sections

Using an R-value = 22 (Selected a higher R-value than the SR 32 Materials Report due to encountered subgrade)

TI = 10.5

$GE_{Required}$ = 0.0032(10.5)(100-22) = 2.62

TI = 10.0

$GE_{Required}$ = 0.0032(10.0)(100-22) = 2.50

TI = 9.5

$GE_{Required}$ = 0.0032(9.5)(100-22) = 2.37

Reviewed by,

[signature] ______________________ [signature] for Eric Nichols

APPENDIX E

Materials Handout Information

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Geotechnical ▪ Construction Services ▪ Forensics

SUMMARY OF INVESTIGATIONS

Investigations performed by Blackburn Consulting and CHEC Management Systems, Inc, (CHEC), indicate that mainline State Route 32 (SR 32) pavement section is suitable for recycling. Fieldwork, analysis, and laboratory testing indicate that the mainline SR 32 pavement section materials, when recycled, will provide sufficient strength to extend the life of the pavement by 10 years. Placement of the planned overlay, in addition to the recycled section, will extend the life of this pavement between 15 and 20 years.

In general the existing structural section of SR 32 includes asphalt concrete, base, and native materials. The base material meets today's standards for 1½" aggregate subbase. We did observe larger cobbles up to 4" in diameter in this base material. The native materials range from a silty gravel with sand to a mixture of sandy lean clay with gravel.

See CHEC's March 2010 for a description of the existing pavement condition along SR 32.

Test pits and coring indicated that the SR 32 pavement consists of between 3.5" and 11" of hot-mix asphalt concrete. For the most part the asphalt in the center left turn lanes is thicker than the travel lanes.

A foamed asphalt mix design was performed using the existing hot-mix asphalt and base materials. For a one foot treatment section, a mixture of 46% AC, 54% base and 2% cement was tested in the laboratory. An optimum foamed asphalt percent of 2.5% yielded average strengths of 62 psi dry and 35 psi wet.