Caltrans

703 B St. Marysville, CA

COLD IN-PLACE RECYCLING OF ASPHALT CONCRETE

On Colusa 16 KP R5.4/11.7 (PM R3.4/7.3)

Innovation Proposal Report

Cold In-Place Recycling of Asphalt Concrete

Proposal Report for a Caltrans Innovative Project

Contact Information

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Rex Hervey	530 741-4119	Program Advisor/ Project Engineer	Dist 03 Maintenance Engineering
Joe Peterson	530 741-5378	Materials Engineer	Dist 03 Materials Engineering
Nik Beach	530 741-4547	Design Engineer	Dist 03 Maintenance Engineering

Description

This project proposes to recycle the existing asphalt concrete, in-situ, on Colusa 16 from KP R5.4/11.7 (PM R3.4/7.3) utilizing asphalt emulsion as the binding agent, herein after referred to as cold in-place recycling.

This project will be the first recycle project used as a maintenance strategy, and the first that requires a project specific mix design, within District 3. It could prove more cost effective to recycle and overlay the entire traveled way rather than removing and replacing the asphalt concrete when the pavement exhibits a high percentage of distress without significant base failure. Recycling is not currently an available option for corrective maintenance work within the Highway Maintenance Guidelines (Ref. "General Guidelines for Effective Maintenance Treatments," rev 07/01/06.).

In this case, cold in-place recycling will consist of milling 50 millimeters of the existing asphalt concrete surface, crushing/sizing the milled material, adding the asphalt emulsion, and additives (cement or lime) if necessary. The resultant recycled mix will then be spread and compacted to the lines and grades of the original pavement. A flush coat consisting of a light application of asphaltic emulsion and sand will be applied to the finished recycled surface. After opening to traffic for at least 7 days, to allow curing of the recycled material, a 30 millimeter overlay of dense grade asphalt concrete will be placed.

This process is consistent with other recycling processes which utilize a "train" method to construct the recycled surface. This "train" consists of one or more units that mill, grade, blend, and spread the recycled material followed by compaction equipment in a continuous operation within a single traffic lane.

Benefits

Environmental benefits are significant. Virtually all existing pavement milled will be reused in the final product. In contrast with removing and replacing asphalt concrete, disposal sites are not required and the need for additional material from a borrow site is reduced or eliminated. This results in a significant reduction in hauling, reducing energy consumption and wear to the highway system.

All pavement cracks within the project limits will be interrupted to the depth of the recycle process, with the assumed benefit of deferred maintenance and rehabilitation.

Rather than overlaying a patchwork of localized digouts with numerous construction joints that inevitably reflect through the overlay, the cold in-place recycling process should provide a high quality, uniform continuous structural section to pave over.

If the maintenance treatment desired is a thin blanket of dense graded asphalt concrete, the need to remove any existing open graded asphalt concrete would be eliminated if recycling is utilized, which could prove cost effective also.

When compared to removing and replacing asphalt concrete, a reduction in delays to the traveling public and safety benefits to both the public and construction work force should be realized since there will be virtually no construction truck traffic exiting or entering the closed lane.

Reduced costs could be realized due to reuse of the existing material, reduced hauling expenses, reduced energy consumption and deferred maintenance and/or rehabilitation.

Selection Criteria

This location was selected to evaluate the performance of the recycled asphalt concrete on a roadway with low traffic volume. If the product performs as expected, its use could be extended to roadways that bear a greater traffic load.

Utilizing as a maintenance strategy, any pavement on a class 3 roadway and potentially class 2 roadways, that display a high percentage of distress without significant base failure (old pavement), relatively low traffic counts and low truck traffic volume, and no foreseeable funding for rehabilitation should be good candidates for this process.

Class 3 roadways should be ideal since heavy truck traffic can be detrimental to the recycled layer during the curing period.

Because precipitation can be detrimental to the recycled layer prior to proper curing construction should be underway only during dry periods. Roadways within environments not highly subject to thunderstorms are preferable.

Specifications

Caltrans specifications for cold in-place recycling are included at the end of this report.

Background

Cold in-place recycling is not new. Successful uses are well documented throughout the world. However this process is not currently an option for use in the Highway Maintenance Program. If proven cost effective it could be another "tool" that can be used in the maintenance of the highway system.

Cold in-place recycling was used as a rehabilitation strategy within District 3 in 1993 (Contract #03-352504, Nev-89-PM 3.4/8.7). Performance records are not available. Discussions with Caltrans personnel working in materials engineering and maintenance engineering at the time the project was built revealed that construction went smoothly but the product did not perform as expected in the long term. The early failure, within two years, was attributed to the lack of pre-engineering (mix design), the high altitude environment, volume of heavy truck traffic and the possibility that the recycled material was overlaid prior to curing properly.

Potential Locations

This location was selected because it is on a class 3 roadway that displays a high percentage of distress without significant base failure, relatively low traffic counts and low truck traffic volume, and no foreseeable funding for rehabilitation.

Some project specifics are: Contract No. 03-2M4604 in Colusa County on Route 16 from KP R5.4/11.7 (PM R3.4 to PM 7.3). The project is scheduled for construction mid to late summer of 2007. Vehicle AADT total is 680; truck AADT total is 96. Moderate to high alligator B cracking exists throughout a large portion of the project limits. It will be necessary to repair about 2% of the total area involved by removing the base and surfacing to a depth of about 150 millimeters and filling the resultant void with asphalt concrete. The pavement condition survey and traffic count index for this location are included at the end of this report.

Estimated Costs and Funding Source

Shakir Shatnawi has allocated $500,000 of Innovative Program funds, the remaining $860,000 will be funded by the Highway Maintenance Program. Below is the draft estimated construction cost:

Rev 2/14/06

2m4601 CONSTRUCTION COST ESTIMATE

Description	Unit	Quantity	Unit Price	Amount
CONSTRUCTION SITE MANAGEMENT	LS	LS	$ 13,300.00	$ 13,300.00
PREPARE SWPPP	LS	LS	$ 6,000.00	$ 6,000.00
CONSTRUCTION AREA SIGNS	LS	LS	$ 3,500.00	$ 3,500.00
TRAFFIC CONTROL SYSTEM	LS	LS	$ 40,000.00	$ 40,000.00
PORTABLE CHANGEABLE MESSAGE SIGN	LS	LS	$ 13,000.00	$ 13,000.00
REMOVE ASPHALT CONCRETE DIKE	m	1176	$ 13.00	$ 15,293.18
RECONSTRUCT MBGR	m	1860	$ 75.00	$ 139,500.00
COLD PLANE AC PAVEMENT	m2	569	$ 26.00	$ 14,804.40
IMPORTED MATERIAL (SHLDER BACKING)	Tonn	461	$ 70.00	$ 32,274.51
REMOVE METAL BEAM GUARD RAILING	m	65	$ 60.00	$ 3,900.00
ALTERNATIVE FLARED TERMINAL SYSTEM	EA	3	$ 2,600.00	$ 7,800.00
ALTERNATIVE IN-LINE TERMINAL SYSTEM	EA	2	$ 3,300.00	$ 6,600.00
END ANCHOR ASSEMBLY (TYPE SFT)	EA	5	$ 900.00	$ 4,500.00
END CAP (TYPE C)	EA	5	$ 200.00	$ 1,000.00
ASPHALT CONCRETE (TYPE A)	Tonn	3860	$ 100.00	$ 386,038.19
COLD IN-PLACE RECYCLING	M2	45000	$ 4.50	$ 202,499.51
EMULSIFIED RECYCLING AGENT	TONN	216	$ 800.00	$ 172,799.58
COLD IN-PLACE RECYCLING ADDITIVE	TONN	54	$ 350.00	$ 18,899.95
REPLACE AC SURFACING	M3	86	$ 550.00	$ 47,406.15
PAVEMENT MARKER (RETROREFLECTIVE)	EA	1673	$ 4.40	$ 7,361.73
100 MM THERMOPLASTIC TRAFFIC STRIPE	m	24407	$ 1.20	$ 29,287.97
100 MM THERMO TS (B 10.98 M - 3.66 M)	m	544	$ 2.50	$ 1,359.86
PLACE ASPHALT CONCRETE DIKE (TYPE C)	m	19	$ 9.00	$ 171.00
PLACE ASPHALT CONCRETE DIKE (TYPE D)	m	154	$ 9.00	$ 1,386.00
PLACE ASPHALT CONCRETE DIKE (TYPE E)	m	222	$ 9.00	$ 1,998.00
PLACE ASPHALT CONCRETE DIKE (TYPE F)	m	781	$ 9.00	$ 7,029.00
OBJECT MARKER (TYPE L-1)	EA	3	$ 100.00	$ 300.00
CLASS 1 DELINEATOR	EA	276	$ 65.00	$ 17,940.00
			SubTotal	**$ 1,195,949.03**
Supplemental				
MAINTAIN TRAFFIC	LS	LS	$ 33,000.00	$ 33,000.00
ADDITIONAL MBGR RAIL ELEMENTS	LS	LS	$ 10,000.00	$ 10,000.00
ADDITIONAL WATER POLLUTION CONTROL	LS	LS	$ 7,500.00	$ 7,500.00
JUST IN TIME TRAINING	LS	LS	$ 1,500.00	$ 1,500.00
REMOVE UNSUITABLE MATERIAL	LS	LS	$ 10,000.00	$ 10,000.00
COMP ADJ FOR AC PRICE FLUCTUATIONS	LS	LS	$ 17,600.00	$ 17,600.00
PARTNERING	LS	LS	$ 5,000.00	$ 5,000.00
			SubTotal	**$ 84,600.00**
State Furnished				
CHP ENHANCED ENFORCEMENT	LS	LS	$ 5,000.00	$ 5,000.00
TMP - PUBLIC AWARENESS	LS	LS	$ 1,000.00	$ 1,000.00
RESIDENT ENGINEERS OFFICE	LS	LS	$ 6,000.00	$ 6,000.00
			SubTotal	**$ 12,000.00**
			Project Subtotal	**$ 1,292,549.03**
			5.0% Contingency	$ 64,627.45
			TOTAL	**$ 1,358,000.00**

Potential Problems, Impacts, and Remedies

The existing pavement properties will be thoroughly investigated and recorded by the District 3 Materials unit. An informational handout with the results of this investigation will be provided to the bidders for use in the preparation of the mix design. As noted elsewhere in this report, the previous rehabilitation project constructed in the early 1990's exhibited premature degradation of the recycled layer. This project did not use a project specific mix design. Premature distress attributed to the mix is not anticipated because the current cold-in place recycle specifications require a project specific mix design.

Precipitation during the recycling and curing process can cause immediate failure of the recycled material. To avoid this construction must take place during extended dry periods. It is preferable to avoid seasons and locations that are subject to thunder storm activity. The specifications prohibit the contractor from recycling during wet conditions, or if precipitation is imminent.

Warranties

Warranty specifications are not available for this process.

Safety

This process is very similar to removing and replacing asphalt concrete, except for the added benefit of reduced construction truck traffic (disposal of grindings and asphalt concrete import), and therefore there are no unusual construction related safety concerns.

Evaluation Plan

District 3 Materials Engineering and Testing will evaluate the project at 1 and 3 years. This evaluation will consist of the following:

- A precondition survey will be performed consisting of a visual survey (photos) and falling weight deflectometer readings at same fixed points about 30 days prior to construction.
- At 1 year a visual survey (photos) and falling weight deflectometer readings at same fixed points and issue interim report.
- At 3 years a visual survey (photos) and falling weight deflectometer readings at same fixed points and issue final report.

District 3 Maintenance Engineering will perform visual inspections annually and in conjunction with the annual Pavement Condition Survey and Materials Engineering establish an "expected life of treatment" that may be used to develop an "equivalent

annual cost." This information could potentially be used for the maintenance treatment selection process.

Definition of Success

This project will be considered a success if the deflection readings do not very by more than 15% between successive years during the three year monitoring period. In addition localized pavement failures within the recycled segment of the structural section do not exceed 3% of the total pavement area recycled.

It will also be considered a success if the results produce an equivalent annual cost that justify including cold in-place recycling as an available option for corrective maintenance work within the Highway Maintenance Guidelines. These results will also benefit the Pavement Rehabilitation Program in selecting appropriate rehabilitation strategies.

Submitters:

Innovators:

Pat Kelley	Maint. Engineer	Dist 03 Maintenance Engineering
Rex Hervey	Program Advisor/ Project Engineer	Dist 03 Maintenance Engineering
Nik Beach	Design Engineer	Dist 03 Maintenance Engineering

Caltrans Champion:

Joseph Peterson	Materials Engineer	Dist 03 Materials Engineering

Attachments

2005 Pavement Condition Survey

Vehicle Count Data

Cold In-Place Recycle Specifications (w/"Method of test for determining the percent of emulsified recycling agent to use for cold recycling of asphalt concrete)

Collection Date: 03/30/2005
Printed: 02/14/2007

Caltrans Maintenance Program
2005 Pavement Condition Survey Inventory
Caltrans Drive Order

District 3, COL, Rte 016, PM 3.2 - 7.3

District	3
County	COL
Route	016
Begin PM	1.200

District 3 County COL Route 016

Begin PM - End PM	Length	LaneMi. (Est.)	Type	AADT (,000)	MSL

	Lane	Surface Type	Alligator Cracking A %	Alligator Cracking B %	Alligator Cracking C (Y/N)?	Rutting, Bleeding	Slab Cracking 1st %	Slab Cracking 3rd %	Slab Cracking Corner %	Faulting	Patching Area %	Patching Poor Cond.?	Ride, IRI	Priority	Skid	Defect
1.200 - 2.531				**1.331**		**2.662**										
	L1	F-CS	0	0									15 124	32		FINE RAVEL
	R1	F-CS	0	32									18 138	13		HIGH ABC
2.531 - 3.223				**0.692**		**1.384**										
	L1	F-CS	0	19		Rutting							33 195	14		MOD ABC
	R1	F-CS	0	13									34 200	14		MOD ABC
R 3.223 - R 3.568				**0.345**		**0.690**										
	L1	F-CS	0	19		Rutting							36 208	14		MOD ABC
	R1	F-CS	0	13									32 194	14		MOD ABC
3.568 - 4.000				**0.432**		**0.864**										
	L1	F-CS	0	19		Rutting							56 289	12		MOD ABC, LOW PAT, RIDE
	R1	F-CS	0	13									48 256	12		MOD ABC, LOW PAT, RIDE
4.000 - 4.237				**0.237**		**0.474**										
	L1	F-CS	22	43									66 326	11		HIGH ABC, RIDE
	R1	F-CS	11	17		Rutting							49 259	12		MOD ABC, LOW PAT, RIDE
R 4.237 - R 4.573				**0.336**		**0.672**										
	L1	F-CS	22	43									36 210	13		HIGH ABC
	R1	F-CS	11	17		Rutting							38 215	14		MOD ABC
4.571 - 5.028				**0.457**		**0.914**										
	L1	F-CS	22	43									38 218	13		HIGH ABC
	R1	F-CS	11	17		Rutting							50 262	12		MOD ABC, LOW PAT, RIDE
5.028 - 6.478				**1.450**		**2.900**										
	L1	F-CS	0	0									32 193	99		NO DISTRESS OBSERVED
	R1	F-CS	0	0									37 213	99		NO DISTRESS OBSERVED
6.478 - 7.256				**0.778**		**1.556**										
	L1	F-DG	0	19									30 186	14		MOD ABC
	R1	F-DG	0	11									33 195	14		MOD ABC

*Surface type of 'EB' is Enhanced Binder.

Caltrans Maintenance Program
2005 Pavement Condition Survey Inventory
Caltrans Drive Order

District 3, COL, Rte 016, PM 3.2 - 7.3

District 3 County COL Route 016

Begin PM - End PM		Length	LaneMi. (Est.)	Type	AADT (,000)	MSL
D 0.320	**- D 0.632**	**0.312**	**0.624**	**2LNU**	**0**	**3**

Lane	Surface Type	Alligator Cracking A %	Alligator Cracking B %	Alligator Cracking C (Y/N)?	Rutting, Bleeding	Slab Cracking 1st %	Slab Cracking 3rd %	Slab Cracking Corner %	Faulting	Patching Area %	Patching Poor Cond.?	Ride, IRI		Priority	Skid	Defect
L1	F-DG	0	19									11	112	14		MOD ABC
R1	F-DG	0	11									16	129	14		MOD ABC

*Surface type of 'EB' is Enhanced Binder.

Printed 02/14/2007

Caltrans Maintenance Program
2005 Pavement Summary
Caltrans Drive Order
District 3, COL, Rte 016, PM 3.2 - 7.3

District	**3**
County	**COL**
Route	**016**
Begin PM	**1.200**

District 3 County COL Route 016

Priority	County	Route	Begin PM		End PM	Length	Pave Type	Dir.	Trig. Dir.	Trig. Ln Mi	AADT (,000)	MSL	Max Allig. A	Max Allig. B	Max Patching	Max Bleeding	Max Rutting	Max 1st St. Crk.	Max 3rd St. Crk.	Max Corner Crk.	Max Faulting	Int'l Rough. Index	Defect
13	**COL**	**016**	**1.200**	**-**	**2.531**	**1.331**	**F**	**B**	**R**	**1.331**	1	3		32								138	HIGH ABC
14	**COL**	**016**	**2.531**	**-**	**3.223**	**0.692**	**F**	**B**	**B**	**1.384**	1	3		19			Rut.					200	MOD ABC
14	**COL**	**016**	**R3.223**	**-**	**R 3.568**	**0.345**	**F**	**B**	**B**	**0.690**	1	3		19			Rut.					208	MOD ABC
12	**COL**	**016**	**3.568**	**-**	**4.000**	**0.432**	**F**	**B**	**B**	**0.864**	1	3		19			Rut.					289	MOD ABC, LOW PAT, RIDE
11	**COL**	**016**	**4.000**	**-**	**4.237**	**0.237**	**F**	**B**	**B**	**0.474**	1	3	22	43			Rut.					326	HIGH ABC, RIDE
13	**COL**	**016**	**R4.237**	**-**	**R 4.573**	**0.336**	**F**	**B**	**B**	**0.672**	1	3	22	43			Rut.					215	HIGH ABC
11	**COL**	**016**	**4.571**	**-**	**5.028**	**0.457**	**F**	**B**	**B**	**0.914**	1	3	22	43			Rut.					262	HIGH ABC, RIDE
99	COL	016	5.028	-	6.478	1.450	F	B		0.000	1	3										213	NO DISTRESS OBSERVED
14	**COL**	**016**	**6.478**	**-**	**7.256**	**0.778**	**F**	**B**	**B**	**1.556**	1	3		19								195	MOD ABC
14	**COL**	**016**	**D0.320**	**-**	**D 0.632**	**0.312**	**F**	**B**	**B**	**0.624**	1	3		19								129	MOD ABC

Total Triggered Lane Miles **8.509**

Note: HA Project locations highlighted in bold typeface.

RTE	DIST	CNTY	POST MILE	LEG	DESCRIPTION	VEHICLE AADT TOTAL	TRUCK AADT TOTAL	TRUCK % TOT VEH	TRUCK AADT TOTAL By Axle 2	3	4	5+	% TRUCK AADT By Axle 2	3	4	5+	EAL 1-WAY (1000)	YEAR VER/ EST
016	03	COL	0	A	JCT. RTE. 20	680	96	14.17	28	11	11	45	29.41	11.76	11.76	47.06	19	00E
016	03	YOL	7.146	A	RUMSEY, MANZANITA AVENUE	1050	134	12.73	48	10	10	67	35.71	7.14	7.14	50	27	00E
016	03	YOL	31.867	B	JCT. RTE. 505	14600	1661	11.38	529	169	116	846	31.85	10.19	7.01	50.96	343	00E
016	03	YOL	32.226	A	JCT. RTE. 505	8200	820	10	234	95	51	439	28.57	11.61	6.25	53.57	176	00E
016	03	YOL	40.57	B	WEST MAIN STREET	11700	1020	8.72	340	136	109	435	33.33	13.33	10.67	42.67	191	00E
016	03	YOL	R40.57	A	WEST MAIN STREET	8600	919	10.69	317	132	73	397	34.53	14.39	7.91	43.17	171	00E
016	03	YOL	R43.42	B	JCT. RTES. 5/50	5300	678	12.8	184	85	42	367	27.08	12.5	6.25	54.17	147	00E
016	03	SAC	T1.658	A	JCT. RTES. 5/50	60000	5400	9	1685	1512	648	1555	31.2	28	12	28.8	830	96E
016	03	SAC	3.015	B	SACRAMENTO, FLORIN-PERKINS ROAD	13200	1188	9	371	334	141	342	31.2	28.1	11.9	28.8	182	96E
016	03	SAC	R11.474	B	SACRAMENTO, SUNRISE BOULEVARD	10100	909	9	284	255	108	263	31.2	28	11.9	28.9	140	96E
016	03	SAC	R16.805	A	LATROBE ROAD	16200	729	4.5	338	110	88	193	46.3	15.1	12.1	26.5	101	96E
016	10	AMA	9.093	B	JCT. RTE. 124 SOUTH	9000	694	7.71	218	150	33	293	31.4	21.6	4.8	42.2	127	97E
016	10	AMA	9.373	B	CENTRAL HOUSE, JCT. RTE. 49	7900	600	7.6	188	130	28	253	31.4	21.7	4.7	42.2	110	97E

+

Use this nSSP to construct a cold in-place recycling project.

Cold in-place recycling during the pilot period will be limited to moderate to low volume roadways.

Do not use:

When pavement reinforcing fabric (PRF) is present within the layer of asphalt concrete that is to be recycled, or

When rubberized asphalt concrete (RAC) is in the existing pavement to be recycled, except RAC(O) may be removed prior to recycling operations.

Cold in-place recycling is restricted to depths of 50-mm to 100-mm. Existing pavement section must be at least 25-mm thicker than the depth of CIR to provide support for the recycling equipment.

Include SSPs and separate item for Asphalt Concrete wearing course over the recycled pavement. Recycling of the existing pavement will provide an essentially smooth base course for the AC layer. Therefore, profilograph requirements need to be included in AC.

Add SP 05-0XX to "Order of Work" and other applicable project specifics. Meet the following moisture requirements: The recycled pavement layer shall remain in place a minimum of 2 days without rainfall and until the moisture content is 1.5% or less prior to the initial layer of asphalt surfacing.

Add SSP 12-270 "Traffic Control System" and include lane closure length and time of closure restrictions in "Maintaining Traffic".

For assistance with site selection, prices for lime and concrete additives, and approval to use this nSSP, contact Hamid Moussavi at Materials Engineering and Testing Services at (916) 227-7234 or by e-mail at hamid_moussavi@dot.ca.gov.

Include SSP S5-200, "Damage Claims"

Include contingency or supplemental funds for "unsuitable material".

1

10-1. __ COLD IN-PLACE RECYCLING

This work consists of milling the existing asphalt concrete pavement to the length, depth, and width as shown on the plans; mixing the cold milled material with emulsified recycling agent and other additives where required; then spreading and compacting the recycled pavement mixture to the lines and grades as specified in these special provisions and as shown on the plans.

2

Attention is directed to "Order of Work" elsewhere in these special provisions.

3

This project is a pilot project to evaluate the construction and performance of cold in-place recycling. No substitute processes or materials will be allowed. The provisions in Section 5-1.14, "Cost Reduction Incentive," of the Standard Specifications shall not apply to cold in-place recycling.

Cold In-Place Recycling is in the Pilot Phase. Just in-time training must be required. A letter of reminder should be included in the RE File.

Include at least $1,500 under Supplemental Work in the Engineer's Estimate to cover payment for an instructor for the Just-In-Time-Training class and his/her lodging, travel, meals, and presentation materials.

4

JUST-IN-TIME TRAINING

Attending a 2-hour minimum Just-In-Time Training (JITT) shall be mandatory, and consist of a formal joint training class on cold in-place recycling materials, equipment, placement, and quality control. Construction operations for cold in-place recycling shall not begin until the Contractor's and the Engineer's personnel have completed the mandatory JITT. The Contractor's personnel involved in cold in-place recycling mix design and quality control, as well as equipment operators and crew involved in the recycling and recycled paving operation, plus the Engineer's representatives including inspectors and testers, shall attend JITT. JITT shall be in addition to the prepaving conference.

5

The JITT class will be conducted for not less than 2 hours on cold in-place recycling operations and recycled paving techniques. The training class may be an extension of the prepaving conference and shall be conducted at a project field location convenient for both the Contractor and the Engineer. The JITT class shall be completed not more than 5 days, not including Saturdays, Sundays or holidays, prior to the start of cold in-place recycling operations. The class shall be held during normal working hours.

6

The JITT instructor shall be provided by the Contractor. The instructor shall be experienced in the construction methods, materials, and test methods associated with construction of cold in-place recycling projects. A copy of the course syllabus, handouts, and presentation material shall be submitted to the Engineer at least 7 days before the day of the training. The Contractor and the Engineer shall mutually agree to the course instructor, course content, and training site.

7

Just-In-Time Training shall not relieve the Contractor of responsibility under the contract for the successful completion of the work in conformance with the requirements of the plans and specifications.

8

SURFACE PREPARATION

Before any recycling work begins, the Contractor shall prepare the existing roadway by:

A. Removing from the entire roadway width dirt, vegetation, standing water, combustible materials, oils, raised roadway markings, and other objectionable materials by sweeping, blading, or other approved method;
B. Accurately referencing the profile and cross slope as shown on the plans for the finished surface of the recycled pavement material;
C. Accurately marking the proposed longitudinal cut lines on the existing roadway surface prior to commencement of cold in-place recycling operations.

9*. Include district address. PS&E submittal should include a Material Information Handout.

MATERIALS

Existing Material

A summary of existing material investigations is available to the Contractor in the "Materials Information" handout. The handout may be obtained from _____.

10

Cold Milled Asphalt Concrete

Existing asphalt concrete pavement shall be cold milled, pulverized, crushed, or sized and screened to conform to the following gradation before mixing with emulsified recycling agent:

Sieve Sizes	Percentage passing
25-mm	100

11

The contractor shall separate any millings larger than 25 mm by screening or other means and break down by mechanical means to pass a 25 mm sieve. Graded millings shall uniformly be incorporated into the recycled pavement mixture and oversized or deleterious material shall be disposed of as provided in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way" of the Standard Specifications.

12

Emulsified Recycling Agent

Emulsified recycling agent shall conform to the requirements of Section 94, "Asphaltic Emulsions", of the Standard Specifications except Tables 1, 2, 3, and 4 are superseded by these special provisions. Emulsified recycling agent shall conform to the following requirements:

	Test Method	Requirement	
		Minimum	Maximum
Tests on emulsion:			
Sieve test, % of weight sample	AASHTO T59[1]	---	0.1
Residue by distillation, %	AASHTO T59[1]	60	67
RAP Coating Test	AASHTO T59[2]	Minimum Good	
Tests on residue by distillation:			
Penetration, 25°C, 100g, 5s (Target Value)[3]	AASHTO T49[4]	+/- 25%	
Absolute Viscosity at 60°C, poise	AASHTO T2171[4]	Report Only	

Note: 1 Modify AASHTO T59 - distillation temperature of 177°C with a 20 minute hold.
2 Mix emulsified recycling agent and water rates shall be determined by the mix design and with jobsite RAP.
3 Target value shall be determined by the mix design
4 Sieve residue from distillation on #20 sieve prior to determining viscosity

13

The Contractor shall provide current test results and a Certificate of Compliance for emulsified recycling agent at the time of mix design submittal and each load of emulsion delivered to the jobsite in conformance with Section 94-1.05, "Test Results" of the Standard Specifications and these special provisions. Test results shall be from an AASHTO accredited laboratory.

14

Four 1-liter samples of emulsified recycling agent shall be submitted to the Engineer as part of the mix design submittal.

15

During cold in-place recycling operations, the Contractor shall obtain two 1-liter samples of emulsified recycling agent from each load delivered to the project. One sample shall be used for the Contractor's quality control testing. The remaining samples shall be delivered to the Engineer at the end of each working day.

16

Emulsified recycling agent shall be sampled in plastic containers that are clean, dry, and sealed. After sampling, care shall be taken such that the emulsified recycling agent sample shall be handled with care and not overheated.

17

Water

Water may be added to facilitate the uniform mixing of the emulsified recycling agent and the cold milled material.

18

Water used for cold in-place recycling shall be clean and free of foreign substances and shall not cause an adverse effect on either the emulsified recycling agent or the recycled pavement mixture. Water added by the milling machine shall be measured, and the rate of added water can be between 0.5 and 5.0 percent of water added by weight of the recycled pavement mixture per the approved mix design unless a greater variation has been directed by the person designated by the Contractor to make adjustments in the field.

19

The quantity of residual recycling agent in the final recycled pavement mixture shall not vary due to the addition of water.

20

Additives

Cement or lime may be added to the cold in-place recycled pavement mixture as determined by the mix design.

21

At the time of the mix design submittal, the Contractor shall inform the Engineer of the process to be used for incorporating cement or lime into the recycling process.

22

Lime slurry shall be produced from high-calcium quicklime or hydrated lime conforming to the provisions in Section 24-1.02, "Materials", of the Standard Specifications.

23

Cement shall conform to the provisions in Section 90-2.01, "Portland Cement", of the Standard Specifications. Cement shall be limited to no more than 1.0 percent by dry weight of cold milled material.

24

A Certificate of Compliance in conformance with the provisions of Section 6-1.07, "Certificates of Compliance", of the Standard Specifications shall be furnished with each delivery of cement or lime. The Certificate of Compliance shall be submitted to the Engineer with a certified copy of the mass of each delivery.

25

MIX DESIGN

At least 14 days prior to beginning the recycling operation, the contractor shall submit a cold in-place recycled asphalt concrete mix design to the Engineer. The mix design is for informational purposes only. The mix design shall be performed by an AASHTO accredited or Caltrans approved laboratory. The Contractor shall determine the rate of emulsified recycling agent and additive to be added to the cold milled reclaimed asphalt pavement (kilograms of emulsified recycling agent per 100 kg of dry millings) as part of the mix design for the recycled pavement mixture. Reclaimed asphalt pavement used in the mix design shall be obtained directly from the project site either by coring or milling, as approved by the Engineer. Based on the characteristics of the reclaimed asphalt pavement taken from the project site, more than one mix design may be required.

26

The mix design for the recycled pavement mixture shall conform to the requirements in Lab Procedure 8, "Method of Test for Determining the Percent of Emulsified Recycling Agent to Use for Cold Recycling of Asphalt Concrete," available on the internet at www.dot.ca.gov/hq/esc/Translab/fpmlab.htm.

28

The recycled pavement mixture shall conform to the following quality requirements throughout cold in-place recycling operations:

Cold In-Place Recycling Mix Requirements

Design Parameters	Requirement
Gradation of Reclaimed Asphalt Pavement (RAP): CT 202	Passing 25-mm (1")
Asphalt Content of RAP: CT 362 or CT 379 or ASTM D 2172 Method B	Report
Bulk Specific Gravity of Compacted Samples [(1)(2)]: CT 308 Method C	Report
Maximum Theoretical Specific Gravity [(2)]: CT 309 (including provisions of Section J)	Report
Air Voids of Compacted and Cured Specimens [(2)]: CT 367 Part B	Report
Marshall Stability, Cured Specimen[(2)]: AASHTO T 245 40°C (104°F)	5,560 N (1,250 lb.) Minimum
Marshall Retained Stability, AASHTO T 245, 40°C (104°F) Based on Moisture Conditioning on Cured Specimen [(2)(3)]	70% minimum
Ratio of Emulsion Residue to Cement _(mass:mass)	3:1 Minimum
Raveling Test, Section 9 of Lab Procedure 8, 10°C (50°F)	Report

Note: 1 100 mm diameter mold compaction based on either 75 blow Marshall each side or gyratory compactor at 30 gyrations

2 Measurement on specimens after 60°C (140°F) curing to constant weight for no less than 16 hours and no more than 48 hours

3 Vacuum saturation of 55 to 75 percent, water bath at 25°C (77°F) for 23 hours, last 30 to 40 minutes in 40°C (104°F) water bath

29

During the mix design, the Contractor shall determine the target values for penetration at 25°C and viscosity at 60°C of the emulsified recycling agent to be used in production of the recycled pavement mixture.

30

The mix design report shall include gradation of millings; recommended water content range as a percentage of dry millings; optimum emulsion content as a percentage of dry millings; amount of additive as a percentage of dry millings; and corresponding density, air void level, absorbed water, Marshall stability, retained stability, and raveling at recommended moisture and emulsion contents. For the emulsified recycling agent and any additives, include the designation, company name, location, residue content, and certificates of compliance.

31

Contractor Responsibility

The Contractor is responsible for the final product. Adjustments may be made in the field to the actual application rate of emulsified recycling agent or additives as needed, as provided by these special provisions, based on the opinion of the Contractor. Any changes made by the Contractor shall be documented in conformance with these special provisions.

32

CONTRACTOR QUALITY CONTROL INSPECTION, SAMPLING, AND TESTING

The Contractor shall perform process and quality control sampling and testing, and exercise management control to ensure that cold in-place recycling and placement conforms to these specifications. The Contractor shall submit a quality control (QC) plan to the Engineer 14 days prior to the start of the operation. The QC plan shall include a recycling and paving plan outlining the sequence of work, including the maximum production rate for cold in-place recycling operations. The Contractor and Engineer shall meet 7 days prior to the start of cold in-place recycling operations to review the QC plan.

33

The Contractor shall provide a testing laboratory and personnel to perform process and quality control sampling and testing during the cold in-place recycling, spreading, compaction, and finishing. The proficiency of testing laboratories and sampling and testing personnel shall be reviewed, qualified, and accredited by the Department's Independent Assurance Program prior to providing services to the project.

34

Sampling and testing shall be performed at a rate sufficient to ensure that cold in-place recycling, placement, compaction, and finishing conforms to these specifications. The Engineer shall have unrestricted access to the laboratory, sampling, testing sites, and all information resulting from mix design and quality control activities. All QC testing results shall be submitted to the Engineer on a daily basis.

35

The project shall be divided into lots of 3000 square meters. The contractor shall control the cold in-place recycling operation as follows:

1. The Contractor shall measure and record the actual recycle depth at each end of the milling drum at least once every 100 m along the cut length.
2. The amount of emulsified recycling agent shall be within 0.5 percent of the job mix formula established in the mix design for the cold in-place recycled asphalt concrete mixture. Emulsion usage shall be recorded for each lot. The percent of emulsified recycling agent shall be determined based on the ratio of emulsion used (mass) to the theoretical dry mass of the millings processed.
3. The Contractor shall measure and report in-place density, and relative compaction for the lot, and shall rework or reprocess any lot not meeting the requirements of these specifications.
4. Sample the recycled material behind the recycling equipment or the sized reclaimed asphalt pavement prior to the addition of the emulsified recycling agent for each lot. If the reclaimed asphalt pavement does not meet the allowable maximum particle size, the test results shall be reported immediately to the Engineer. The Contractor shall reprocess the material or take other corrective action to attain conformance.

    - On every third sample taken, the Contractor shall perform a wet field gradation for material passing the 25 mm through 4.75 mm sieves. The Contractor shall compare the sieved sample to the gradation band determined from the mix design and adjust the emulsified recycling agent as needed.

36

For each lot, the Contractor shall provide the following information:

1. Length, width, depth of cut; and calculated mass (tonnes) of reclaimed asphalt pavement processed.
2. Amount of emulsified recycling agent added (tonnes), and the amount of emulsified recycling agent added compared to the total mass of the reclaimed asphalt pavement processed in the lot (percentage).
3. Amount of any dry additives used (tonnes) and the amount of additive mass compared to the total mass of the reclaimed asphalt pavement processed in the lot (percentage).
4. Maximum particle size of the recycled material or the sized reclaimed asphalt pavement prior to the addition of the emulsified recycling agent.
5. Nuclear gage readings of in-place density and calculated relative compaction (based on the maximum density defined by the most appropriate rolling vs. density chart) at 10 random locations.
6. Copy of the rolling vs. density chart containing time and location of test strip that is basis for relative compaction calculations.
7. Ambient and compacted recycled surface temperatures.

37

Some sections of the pavement being recycled may require field adjustment for optimum results. For any changes made by the Contractor from one lot to the next, the Contractor shall document the reason for the change and identify each lot where such changes were made.

38

TEST STRIP AND START UP PROCEDURES

The first day of operations, the Contractor shall construct (within the limits to be cold in-place recycled pavement) a test strip of a single lane width and no more than 1500 meters in length. The test strip section shall:

A. Demonstrate that the equipment, materials, and processes proposed can produce a recycled pavement material layer that conforms to the requirements of these special provisions;
B. Determine the optimal rates for emulsified recycling agents, additives, and water recommended for the reclaimed asphalt pavement; and
C. Determine the sequence and manner of rolling necessary to obtain the density requirements of these special provisions.

39

The Contractor shall provide a sequence and manner of rolling which will define maximum compaction by establishing a rolling vs. density chart that shows the progress of densification from initial laydown through maximum obtainable density at the "break over point". The Contractor will determine relative compaction on the quantity within the test strip by measuring nuclear gage density at 10 random locations and computing the relative compaction.

40

If the relative compaction of quantity within the test strip or any lot does not meet the density requirements of these special provisions, the Contractor shall construct additional test strips to define the maximum density obtainable for the millings being produced; the rates of emulsified recycling agents, additives, and water; and the site conditions.

41

Cold in-place recycling operations may continue through the first day, unless the Contractor's equipment and process fail to meet the requirements for successful completion of cold in-place recycling operations in conformance with these special provisions. Recycling operations shall not continue until a test strip conforming to the special provisions has been constructed and approved by the Engineer. Test strips that do not conform to the special provisions shall be reworked, re-compacted, or removed and replaced at the Contractor's expense.

42

Upon acceptance of the test strip by the Engineer, the Contractor shall use the same equipment, materials, and construction methods for the remainder of recycling operations, unless adjustments are made by the Contractor and approved by the Engineer. If adjustments are made, the Contractor will produce a new test strip to define the maximum density.

43

The Contractor shall provide a report as outlined in "Contractor Quality Control Inspection, Sampling, and Testing" of these special provisions.

44

PROPORTIONING

Weighing and measuring devices used for the proportioning of ingredients, except continuous weigh belts, shall have been Type-approved by the Division of Measurement Standards, Department of Food and Agriculture, State of California. Weighing and measuring devices used in the proportioning of slurry shall be tested in conformance with California Test 109 and these special provisions.

45

Portland Cement or Lime Slurry by Continuous Mixing

When a continuous proportioning operation for the production of slurry is used the proportioning device shall determine the exact ratio of water to lime at all production rates. Rate-of-flow indicators and totalizers for like materials shall be accurate within 0.5 percent when compared directly. The following methods shall be used:

A. Portland cement or dry lime shall be weighed using a belt scale. Belt scale accuracy shall be such that, when operating between 30 percent and 100 percent of production capacity, the average difference between the indicated mass of material delivered and the actual mass delivered will not exceed 0.5-percent of the actual mass for 3 individual runs. For any of the 3 individual runs, the indicated mass of material delivered shall not vary from the actual mass delivered by more than one percent of the actual mass. Test run duration shall be for at least 0.5-tonne of cement or lime. Tests shall be run using cement or lime, as appropriate, and shall be weighed on a certified scale.
B. Water to be used in the slurry shall be measured with a meter. Meter accuracy shall be such that, when operating between 50 percent and 100 percent of production capacity, the difference between the indicated mass of water delivered and the actual mass delivered shall not exceed one percent of the actual mass for 3 individual runs. Tests shall be weighed on a certified scale. Test run duration shall be for at least 1150 liters.
C. Meters and scales used for the continuous proportioning of cement or lime and water shall be equipped with rate-of-flow indicators to show the rates of delivery of cement or lime and water and resettable totalizers so that the total amounts of cement or lime and water

introduced into slurry storage tank can be determined. Individual feeds for water and cement or lime shall be equipped with no-flow devices that stop slurry production when either of the individual ingredients is not being delivered to the slurry storage tank.

46

Portland Cement or Lime Slurry by Batch Mixing

When a batch type proportioning operation for the production of slurry is used the following methods shall be used:

A. Portland cement or dry lime shall be proportioned by mass. The weighing of the cement or lime shall be performed at a certified scale.
B. Water to be used in the slurry shall be measured with a meter. Meter accuracy shall be such that, when operating between 50 percent and 100 percent of production capacity, the difference between the indicated mass of water delivered and the actual mass delivered shall not exceed one percent of the actual mass for 3 individual runs. Tests shall be weighed on a certified scale. Test run duration shall be for at least 1150 liters.
D. The water meter shall be equipped with a resettable totalizer. When an automatic controller is used to batch the cement or lime it shall also control the proportioning of the water. When an automatic controller is used to proportion the water the indicated draft of the water shall be within one percent of its total draft mass.

47

Proportioning During the Cold In-Place Recycling Operation

Cement or lime slurry shall be metered or weighed into the mass of the cold milled material using a mass flow, coriolis effect, type meter that will accurately measure the amount of cement or lime slurry to within 5 percent of the amount required by the mix design or as adjusted in the field.

48

Emulsified recycling agent shall be metered or weighed into the mass of the cold milled material using a mass flow, coriolis effect, type meter that will accurately measure the amount of emulsified recycling agent to within 0.5 percent of the amount required by the mix design or as adjusted in the field.

50

Scales used to calibrate proportioning devices used in the addition of lime or cement shall conform to the provisions in Section 9-1.01, "Measurement of Quantities" of the Standard Specifications and shall be error tested in conformance with California Test 109 within 72 hours of calibrating the proportioning devices.

51

COLD IN-PLACE RECYCING EQUIPMENT

General

The recycling train shall be capable of milling and crushing or sizing the existing asphalt pavement. The equipment used for mixing the cold millings with the emulsified recycling agent and additive shall be capable of producing a homogeneous and uniformly coated recycled pavement mixture. The equipment used for placement of the recycled pavement mixture shall be capable of placement to the lines, grades, and requirements specified in these special provisions and shown on the plans.

52

The Contractor shall have available on the site of the work all equipment and materials to be

used for recycling operations. The recycling train shall consist of the following major components:

53

Pavement Milling Machine

The pavement milling machine shall be self-propelled. The primary milling equipment shall have a minimum 3.6 m cutter capable of removing the existing pavement to the depths shown in the plans. Milling equipment shall be equipped with automatic depth controls capable of maintaining the cutting depth to within 6-mm of the desired depth, and shall have a positive means for controlling cross slope.

54

The milling operation shall not disturb or damage the underlying material. The use of a heating device to soften the pavement will not be permitted.

55

A smaller milling machine may be used to mill the shoulders and miscellaneous areas.

56

Crushing or Sizing Equipment

Crushing or sizing equipment shall be capable of producing reclaimed asphalt pavement to the size required prior to mixing millings with emulsified recycling agent.

57

Mixing and Proportioning Equipment

The mixing equipment shall be capable of mixing the cold milled reclaimed asphalt pavement, emulsified recycling agent, water, and any additives to produce a completely and uniformly mixed, homogeneous recycled pavement mixture.

58

Weighing and measuring devices used for the proportioning of ingredients, except continuous weigh belts, shall have been Type-approved by the Division of Measurement Standards, Department of Food and Agriculture, State of California. Weighing and measuring devices used in the proportioning of cold in-place material shall be tested in conformance with California Test 109 and these special provisions.

59

Pugmill

The recycle train shall have a continuous pugmill mixing plant with a belt scale or integrated microprocessor control system to control the mass of the cold milled reclaimed asphalt pavement being delivered to the mixing chamber and automatic controls to obtain the proper amount of recycling agent and additives being delivered.

60

The pugmill shall be equipped with paddles of a type and arrangement to provide sufficient mixing action and movement to the cold milled reclaimed asphalt pavement, emulsified recycling agent, and additive to produce properly mixed recycled pavement mixture. The cold milled reclaimed asphalt pavement shall be fed from the crushing or sizing equipment to the mixer at a uniform and controlled rate. Mixing shall continue until a thoroughly and uniformly coated recycled pavement mixture of unchanging appearance is produced at discharge from the mixer.

61

Water Storage and Supply Equipment

The recycle train shall have an independent source of water to properly disperse the emulsified recycling agent. This source of water shall be interlocked with the weighing device or microprocessor for the measurement of the millings.

62

The source of water shall be independent of the cement or lime slurry.

63

Portland Cement or Lime Slurry Storage and Supply Equipment

Portland cement or lime slurry storage and supply equipment shall have agitators or similar equipment to keep the cement or lime slurry in suspension when held in the slurry feed tank. Cement or lime slurry shall be kept in suspension during transport using agitator equipment.

64

Mixing and Spreading of Cement and Lime

Cement or lime slurry shall be produced at the jobsite as required by these specifications. The Contractor shall provide the Engineer with batch logs daily.

65

Lime or cement slurry may be added directly to the pugmill or sprayed over the cutting teeth of the milling machine.

68

Spreading Equipment

The spreading equipment shall be a paver and shall conform to the requirements of Section 39-5.01, "Spreading Equipment," of the Standard Specifications. Pavers shall have a minimum power of 127 kW. The asphalt paver loading equipment shall be capable of picking up substantially all of the recycled pavement material and depositing it in the paving machine. If the paving screed is directly attached to the cold recycling equipment, the recycled material shall be fed directly to the paving screed.

69

Compacting Equipment

Compacting equipment shall conform to the requirements of conform to the provisions in Section 39-5.02, "Compacting Equipment", of the Standard Specifications. The contractor shall provide a minimum of 1 pneumatic-tired roller weighing at least 22.7 tonnes each and 2 double drum vibratory steel-wheeled rollers weighing at least 9.1 tonnes. Rollers shall have a width of not less than 1.7 m. All rollers shall have working water spray systems.

70

CONSTRUCTION

No cold in-place recycling work shall be performed during wet conditions, nor started if rain is imminent when the work is to be performed. No recycling work shall be performed unless the pavement temperature is a minimum of 16°C and ambient temperature is a minimum 10°C and rising. Recycling operations other than compaction shall be completed a minimum of 2 hours before sunset.

71

The Contractor shall ensure that there is no gap of un-recycled pavement material created between successive cuts (along the same longitudinal cut line), nor wedges of un-recycled pavement material created by the entry of the milling drum into the existing material. Longitudinal joints between successive cuts shall overlap a minimum of 100 mm.

72

Any unsuitable subgrade material encountered shall be excavated and disposed of in accordance with Section 19-2.02 of the Standard Specifications. Unless otherwise directed by the Engineer, the resulting space shall be backfilled with Class 2 Aggregate Base in conformance with Sections 26-1.04, "Spreading," and 26-1.05, "Compacting," of the Standard Specifications and these special provisions.

73

The Class 2 Aggregate Base shall be topped with Type A or B asphalt concrete or premixed bituminous surfacing equivalent in thickness to the existing asphalt concrete layer adjacent to the excavation. If premixed bituminous surfacing is used, it shall be removed and replaced with Type A or B asphalt concrete prior to placement of the final asphalt concrete surface. Asphalt concrete shall be placed in layers and compacted until the level of the existing road is reached.

74

The Contractor shall submit a contingency plan to the Engineer at least 14 days prior to starting the cold in-place recycling operation. The contingency plan shall describe the corrective actions the Contractor will use in the event of equipment break down. The corrective actions shall include provisions to repair and reopen the roadway to traffic, at the expense of the Contractor, using conventional asphalt concrete, cold mix asphalt concrete, or other materials approved by the Engineer.

75

SPREADING AND COMPACTION

Prior to pick up by the paver, remove and dispose of all visible oversized crack filler in the cold milled material or in the recycled pavement mixture.

76

The recycled pavement mixture shall be graded and compacted to the depth, lines, and grades established by the plans or Engineer and as required by these special provisions.

77

The recycled pavement mixture shall exit from the mixing chamber in a manner that prevents particle segregation. Care shall be exercised while spreading to avoid segregation, tearing, or scarring of the final compacted surface.

78

Rolling shall commence at a time interval following the milling, mixing, and spreading of the recycled pavement mixture as determined by the mix design or directed by the Contractor. Time intervals shall be based on ambient temperatures, weather, and type of emulsified recycling agent. When possible, rolling shall not be started or stopped on uncompacted material.

79

Compacting of the recycled pavement mixture shall be completed using rollers meeting the requirements of these special provisions.

80

The rolling pattern shall be changed when-:

Relative compactioncan not meet the requirements of these specifications.

1. There are changes in recycled pavement mixture or proportions.
2. There are changes in placement equipment or procedures.
3. There is a significant change in temperature or weather conditions or controlling factor.
4. There is major displacement and/or cracking of the recycled pavement mixture.

A new rolling pattern will be established based on a new test strip.

81

The final compacted surface of the recycled pavement mixture shall be free of ruts, bumps, indentations, raveling, irregularities, or segregation and shall meet the smoothness requirements of these specifications.. Cold in-place recycled asphalt concrete that does not conform to these special provisions shall be reworked, re-compacted, or removed and replaced at the Contractor's expense.

84

Initial Compaction

After compaction but prior to opening the roadway to traffic, the average in-place density shall be determined based upon nuclear gage readings of 10 random locations. During in-place density testing of the compacted recycled pavement, the nuclear gauge shall be set to the recycled section thickness.

85

The average in-place density shall be used to calculate the relative compaction for each lot. The relative compaction shall be not less than 95 percent or grater than 105 percent of the maximum density obtained in the test strip as required in these special provisions.

86

If additional rolling does not achieve relative compaction, a new rolling pattern shall be established such that a new maximum density is determined. However, care should be taken not to over-roll the mat based on visual observations of check cracking or shoving.

89

After initial compaction has been achieved, and prior to opening the recycled pavement mixture to traffic, the Contractor shall apply a flush coat to the recycled pavement surface. The flush coat shall be emulsified asphalt that has been diluted 50 percent by volume with water. The flush coat shall be applied to the finished surface at a rate of 0.25 to 0.55 liters per square meter (0.05 to 0.12 gallons per square yard). The rate of application shall be determined by the Contractor and shall be such that a stable and safe roadway surface can be maintained until the surface is overlaid. Immediately following application of the flush coat, the cold in-place recycled pavement surface shall be covered with sand at a rate of 1.0 to 2.0 pounds per square yard (0.5 to 1.0 kg per square meter). The exact rate will be determined by the Contractor. Excess sand shall be removed from the pavement surface by sweeping. Sand shall be free from clay or organic material.

90

The recycled pavement shall remain in place prior to placement of the initial asphalt concrete

layer either:

A. For a minimum of 2 days and until there is less than 1.5 percent moisture remaining in the cold in-place recycled pavement mixture; or
B. A minimum of 10 days without rainfall.

90a

The recycled pavement shall be covered with the initial asphalt concrete layer in the same construction season. The contractor is responsible for maintenance of the recycled pavement mixture during winter and any damaged area shall be replaced with the same depth of hot mix asphalt.

91

Any subsequent surface treatment or overlay of the recycled pavement shall not be placed until the relative compaction of the recycled pavement layer is not less than 95 percent or greater than 100 percent of the maximum density determined by a test strip conducted on the recycled pavement at the time of paving.

92

Release to Traffic

Prior to opening the recycled pavement to traffic, signs shall be furnished and placed adjacent to both sides of the traveled way where recycling operations are being performed on a traffic lane. The first C6 sign in each direction shall be placed where traffic first encounters a recycling location, regardless of which lane the recycling is being performed on. The W6 (35) signs need not be placed in those areas with posted speed limits of less than 40 MPH. The signs shall be placed at maximum 600-m intervals along each side of the traveled way and at public roads or streets entering the recycled pavement surface area as directed by the Engineer.

93

The C6 and W6 signs shall be maintained in place at each location until the initial layer of asphalt concrete surfacing at that location is completed. The C6 and W6 signs shall conform to the provisions for construction area signs in Section 12, "Construction Area Traffic Control Devices," of the Standard Specifications. The signs may be set on temporary portable supports with the W6 below the C6 or on barricades with the W6 sign alternating with the C6 sign.

94

The Contractor shall be responsible for protecting and maintaining the recycled pavement material layer until the initial layer of asphalt surfacing is placed. Any repairs required shall be at the Contractor's expense. Any damage or defects in the layer shall be repaired immediately. An even and uniform surface shall be maintained.

95

Smoothness

96

The finished recycled pavement surface shall be profiled by the Contractor in the presence of the Engineer. Two profiles shall be obtained in each lane. The profiles shall be approximately one meter from and parallel with the edge of the lane.

97

Profiles shall be performed using a California Profilograph or equivalent in conformance with the requirements in California Test 526 and as specified in these special provisions. Prior to beginning profiles, the profilograph shall be calibrated in the presence of the Engineer.

98

High point areas in the finished recycled pavement surface with deviations indicated by the profilograph in excess of 7.5 mm within a length of 7.5 m or less shall be corrected by the Contractor

99

Profile requirements will not apply to the following areas, but these areas shall conform to the straightedge requirements.

A. Horizontal curves with a centerline curve radius of less than 300 m and pavement within the superelevation transition for those curves.
B. Ramps and connectors with grades 8 percent or steeper, and with superelevation rates greater than 10 percent, as determined by the Engineer.
C. City or county streets and roads.
D. Turn lanes and collector lanes that are less than 500 meters in length.
E. Shoulders and miscellaneous areas.
F. Pavement placed one meter from and parallel with the joint between asphalt concrete pavement and existing curbs, gutters or existing pavement.
G. Pavement within 15 m of a transverse joint that separates the pavement from an existing pavement, approach slab or structure surface not constructed under the contract.

100

Profilograph operations shall be in conformance with the lane closure requirement in "Maintaining Traffic" of these special provisions. The profilograph operation shall be complete prior to preliminary acceptance.

101

When a straightedge 3.6 m ± 0.06-m long is laid on the finished recycled surface and parallel with the centerline, the surface shall not vary more than 3 mm from the lower edge of the straightedge. The transverse slope of the finished surface shall be uniform to a degree such that no depressions greater than 6 mm are present when tested with a straightedge 3.6 m ± 0.06-m long laid in a direction transverse to the center line and extending from edge to edge of a 3.6-m traffic lane.

102

Areas of the completed surface that do not meet the specified surface tolerances shall be brought within tolerance by a method chosen by the Contractor and approved by the Engineer. .

103

Deviations in excess of 7.5 mm that cannot be brought into specified tolerance shall be corrected by removal and replacement. Replaced material shall meet the tolerances specified above. Corrective work shall be at the Contractor's expense except that flagging costs will be paid for in conformance to the provisions in Section 12-2, "Flagging," of the Standard Specifications. The Contractor shall profile the areas that have received corrective work until the final profile of the area is within the specified tolerance.

104

The originals of the final profilograms that indicate the completed surface conforms with the profile requirements shall become the property of the State and shall be delivered to the Engineer prior to acceptance of the contract.

105

The Contractor shall provide, while performing profilograph and straightedge operations, a shadow vehicle. The shadow vehicle shall consist of a truck mounted crash cushion conforming to "Traffic Control System for Lane Closure" of these special provisions. The shadow vehicle shall operate within a stationary lane closure. The shadow vehicle shall maintain a 23 to 25 meter distance from the profilograph or straightedge operation at all times.

106

MEASUREMENT

Cold in-place recycling shall be measured by the square meter. The area to be paid for will be calculated on the basis of accepted work completed to the dimensions shown on the plans, adjusted by the amount of any change ordered by the Engineer. Cold in-place recycling performed outside those dimensions will not be measured or paid for. Test strips conforming to the requirements of these special provisions will be included in the quantity to be paid for.

107

Quantities of emulsified recycling agent to be paid for as contract items of work will be determined in accordance with the methods provided in 94, "Asphaltic Emulsions."

108

Additives will be measured by the tonne in conformance with the provisions in Section 9-1.01, "Measurement of Quantities."

109

PAYMENT

The contract price paid per square meter for cold in-place recycling shall include full compensation for furnishing Just-In-Time Training, all labor, materials (including, water, emulsion for flush coat, and sand for sand blotting), tools, equipment, and incidentals; for doing all the work involved in cold in-place recycling, complete in-place (including preparation of the existing roadway surface and referencing the profile and cross slope of existing pavement); for mixing, blending, placing, and compacting the recycled pavement mixture; for reworking all material in overlapping adjacent cuts; for protection and maintenance of the recycled layer; for performing all testing (including mix design, gradation, and relative compaction tests); for re-establishing the profile and cross slope grade for the finished surface of the recycled layer; for calibrating equipment; for obtaining measurements and recording results of all tests; and for furnishing, placing, maintaining, and removing signs and temporary supports or barricades for the signs, as shown on the plans, as specified in these special provisions, and as directed by the Engineer.

110

Emulsified recycling agent will be paid for at the contract price per tonne for emulsified recycling agent. No adjustment of compensation will be made for any increase or decrease in the quantities of emulsified recycling agent required, regardless of the reason for the increase or decrease. The provisions in Section 4-1.03B, "Increased or Decreased Quantities," shall not apply to emulsified recycling agent.

111

Additive will be paid for at the contract price per tonne for additive. No adjustment of compensation will be made for any increase or decrease in the quantities of additive required, regardless of the reason for the increase or decrease. The provisions in Section 4-1.03B, "Increased or Decreased Quantities," shall not apply to additive.

DEPARTMENT OF TRANSPORTATION
ENGINEERING SERVICE CENTER
Office of Flexible Pavement Materials
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Lab Procedure # 8

METHOD OF TEST FOR DETERMINING THE PERCENT OF EMULSIFIED RECYCLING AGENT TO USE FOR COLD RECYCLING OF ASPHALT CONCRETE

1. SCOPE

This procedure is used to determine the percent and grade of recycling agent to use for recycling asphalt concrete when the cold method of recycling is used.

2. COLD MIX REQUIREMENTS

The recycled pavement mixture shall conform to the following quality requirements shown in Table 1.

Table 1: Cold Mix Requirements

Design Parameters	Requirement
Gradation of Design Reclaimed Asphalt Pavement (RAP), CT202	Passing 25-mm (1")
Asphalt Content of RAP, CT362 or CT379 or CT382	Report
Bulk Specific Gravity of Compacted Samples [1] [2], CT308, Method C	Report
Maximum Theoretical Specific Gravity [2], CT309 with Provisions of Section J	Report
Air Voids of Compacted and Cured Specimens [2], CT367 Part B	Report
Marshall Stability, Cured Specimen [2], AASHTO T 245, 40°C (104°F)	5,560 Newton (1,250 Lb.) Minimum
Marshall Retained Stability, AASHTO T 245, 40°C (104°F) Based on Moisture Conditioning on Cured Specimen [2] [3]	70% minimum
Ratio of Emulsion Residue to Cement	1.8 Minimum
Raveling Test, Section 9 of this Document, 10°C (50°F)	Report

Note: 1 100 mm diameter mold compaction based on either 75 blow Marshall each side or gyratory compactor at 30 gyrations
2 Measurement on specimens after 60°C (140°F) curing to constant weight for no less than 16 hours and no more than 48 hours
3 Vacuum saturation of 55 to 75 percent, water bath at 25°C (77°F) for 23 hours, last 30 to 40 minutes in 40°C (104°F) water bath

3. PREPARATION OF SAMPLES

SAMPLING & PROCESSING OF EXISTING ASPHALT PAVEMENT MATERIALS

Obtain RAP samples from the areas to be recycled. It is recommended to take one core for each lane mile and where visual differences in the pavement are noticed.

If cores show significant differences in various areas, such as different type or thickness of layers between cores, then separate mix designs will be performed for each of these pavement segments.

Cores will be cut to the depth specified for the cold recycling project.

Milled RAP from the areas to be recycled or alternate means of obtaining RAP samples can be used as an alternative to cores.

Obtain sufficient RAP, approximately 156 kg (350 lbs), to be used for mix design purposes.

Obtain representative sample of the RAP to be recycled and determine asphalt content of the RAP according to CT362 or CT379 or CT382.

Perform two mix designs, one for each grading, by recombining the RAP material in the laboratory in order to meet the gradation criteria shown in Table 2.

Table 2: Cold Recycling Gradation Requirements

Sieve Size	Suggested Target	
	Medium Gradation	Coarse gradation
25-mm (1")	100	100
19-mm (¾")	95 ± 2	85 ± 2
4.75-mm (No. 4)	50 ± 2	40 ± 2
600-µm (No. 30)	10 ± 2	5 ± 2
75-µm (No. 200)	0.8 ± 0.3	0.3 ± 0.3

Gradation of the RAP after milling or crushing will be determined by California Test CT 202 with the exception that drying of RAP samples to constant mass shall be performed at 40±2°C (104±4°F).

4. MIXING

Specimen size:

Determine the amount that will produce a 61.0 mm to 66.0 mm (2.4" to 2.6") tall specimen when compacting 100 mm (4") diameter specimens with either the Marshal compactor based on 75 blows on each side or the gyratory compactor at 30 gyrations for stability testing.

Number of specimens:

Choose three emulsion contents that bracket the estimated recommended emulsion content for all stability testing outlined in Table 1. Select three emulsion contents in either 0.5% or 1.0% increments covering a range typically between 0.5% and 4.0% by dry weight of RAP.

Compact 6 samples at each emulsion content for stability testing, 3 for Marshall stability on cured samples and 3 for Marshall stability on cured samples for moisture conditioning.

Two specimens are required for Theoretical Maximum Specific Gravity according to CT309, Section J, with the exception that loose RAP mixture shall by cured in an oven at 60±1°C (140±2°F) to constant weight but no more than 48 hours and no less than 16 hours. Constant weight is defined here as 0.05% change in weight in 2 hours. Do not break any agglomerates which will not easily reduce with a flexible spatula. Test both specimens at the highest emulsion content in the design and back calculate for the lower emulsion contents.

Add moisture that is expected to be added at the milling head, typically 1.5 to 2.5 percent.

If any additives are in the mixture, introduce the additives in a similar manner that they will be added during field production.

Mixing of test specimens will be performed manually or with a mechanical bucket mixer or a combination of the two. Mix the RAP thoroughly with water first, then mix with emulsion. Mix at room temperature of 25±2°C (77±4°F). One specimen will be mixed at a time. Mixing time with emulsion should not exceed 60 seconds.

5. COMPACTION

Compact specimens after mixing. Compact specimens at room temperature 25±2°C (77±4°F).

Specimens will be compacted with a Marshall compactor by applying 75 blows per side for stability testing purposes using 100 mm (4") molds or with gyratory compactor at 30 gyrations for stability testing purposes using 100 mm (4") molds.

Do not heat molds or Marshall compaction hammer.

If paper disks are used, place paper disks on the top and bottom of the specimen before compaction and remove paper disks from specimens immediately after compaction.

6. CURING AFTER COMPACTION

Extrude specimens from molds after compaction without damaging the samples. Carefully remove paper disks if used.

Place specimens in 60±4° C (140±8°F) forced draft oven with ventilation on sides and top. Place each specimen in a small container to account for material loss from the specimens. Cure compacted specimens at 60±1° C (140±2°F) to constant weight but no more than 48 hours and no less than 16 hours. Constant weight is defined here as 0.05% change in weight in 2 hours. After curing, cool specimens at ambient temperature a minimum of 12 hours and a maximum of 24 hours.

Perform same oven conditioning and volumetric measurements on moisture-conditioned specimens as on other specimens.

Perform moisture conditioning on 3 compacted samples at each emulsion content by applying a vacuum of 13 to 67 kPa absolute pressure (254 to 660 mm of Hg partial pressure) for a time duration required to vacuum saturate samples to 55 to 75 percent. Saturation calculation shall be calculated by comparing saturated surface dry mass with dry mass in air determined. Soak moisture conditioned samples in a 25±1°C (77±2°F) water bath for 23±1 hour, followed by a 30 to 40 min soak at 40±1°C (104±2°F).

7. MEASUREMENTS

Determine asphalt content of the RAP material to be recycled according to CT362 or CT379 or CT382.

Determine bulk specific gravity of each compacted, cured and cooled specimen according to CT308, Method C.

Determine specimen heights according to CT308 Section D2e. Alternatively, the height can be obtained from the SGC readout if the gyratory compactor is used.

Determine maximum theoretical specific gravity, CT309, Section J, with the exception detailed in Section 4 of this document.

Determine air voids of the compacted and oven cured samples at each emulsion content according to CT367 Part B.

Determine corrected Marshall stability by AASHTO T245 at 40±1°C (104±2°F) after 2 hour temperature conditioning in a forced draft oven or by immersing in water bath for 30 to 40 minutes. This testing will be performed at the same time that the moisture-conditioned specimens are tested.

Determine Marshall Retained Stability. The average moisture conditioned specimen strength divided by the average dry specimen strength is referred to as retained stability.

8. EMULSION CONTENT SELECTION

Choose the design emulsion content such that the cold mix requirements listed in Table 1 are met.

9. RAVELING TEST ON RECYCLED ASPHALT SPECIMENS

Apparatus:

The apparatus used for the raveling test is a modified A-120 Hobart mixer and abrasion head (including hose) used in the Wet Track Abrasion of Slurry Surfaces Test (ISSA TB-100). The

rotation speed for the raveling test is not modified from ISSA TB-100. The ring weight is removed from the abrasion head for the raveling test below. The weight of the abrasion head and hose in contact with the specimen should be 600 +/- 15g.

The prepared sample must be able to be secured under the abrasion head, and centered for accurate results, allowing for free movement vertically of the abrasion head. The device used for securing and centering the sample must allow a minimum of 10 mm of the sample to be available for abrasion. The Hobart mixer will need to be modified to allow the sample to fit properly for abrasion. The modification may be accomplished by adjusting the abrasion head height, or the height of the secured sample. A Raveling Test Adapter can be purchased through Precision Machine and Welding, Salina, KS, (785) 823-8760. Please reference the Hobart Model number when ordering. The C-100 and N-50 Models are not acceptable for this test procedure due to differences in size and speed of rotation.

Procedure:

Split out two 2700 g RAP samples from the crushed core materials. 2700 g is an approximate weight to give 70 +/- 5 mm of height after compaction.

Place the 2700 g of RAP in a container of adequate size for mixing.

Field or design moisture contents should be added to each of the RAP samples and mixed for 60 seconds.

Add the design emulsion content and mix for 60 seconds.

Immediately following mixing, place samples into a 150 mm compaction mold and compact to 20 gyrations. If the sample height is not 70 +/- 5 mm, the RAP weight should be adjusted.

After compaction, remove samples from the compaction mold and placed on a flat pan to cure at ambient lab temperature (65-75°F) for 4 hours +/- 5 minutes.

Weigh the specimens after curing and just prior to testing.

Place the specimens on the raveling test apparatus. Care should be taken that the specimen is centered and well supported. The area of the hose in contact with the specimen should not have been previously used. It is allowable to rotate the hose to an unworn section for testing. The abrasion head (with hose) will be free to move vertically downward a minimum of 5mm if abrasion allows.

Abrade samples for 15 minutes and immediately weigh abraded samples.

Determine the Percent Raveling Loss as follows:

$$Percent\ Raveling\ Loss = \frac{(Weight\ prior\ to\ test - Weight\ after\ abrasion)\ x\ 100}{Weight\ prior\ to\ test}$$

The average of the results of tests on the two specimens will be reported as the Percent Raveling Loss.

There should not be a difference of 0.5% Raveling Loss between the two test specimens for proper precision. A difference of greater than 0.5 percent will require the test to be repeated. If both of the samples have a Raveling Loss of greater than 10%, the precision requirement will be waived and the average of the two tests will be computed regardless of the difference between the two tests.

10. REPORT

The report will contain the following minimum information: gradation of RAP, RAP asphalt content, recommended water content range as a percentage of dry RAP, optimum emulsion content as a percentage of dry RAP, amount of additive as a percentage of dry RAP, ratio of emulsion residue to cement, and corresponding density, air void level, Marshall stability, retained stability, compaction method used to determine any reported stability, and raveling at recommended moisture and emulsion contents. Include the emulsion and additive designation, company name and location; and residue content; and the additive designation, company name and location; and certificates of compliance for both.