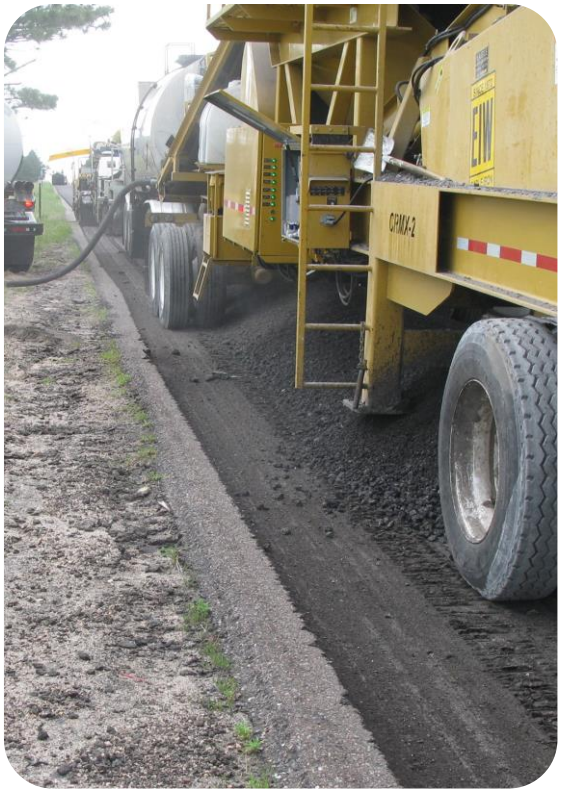
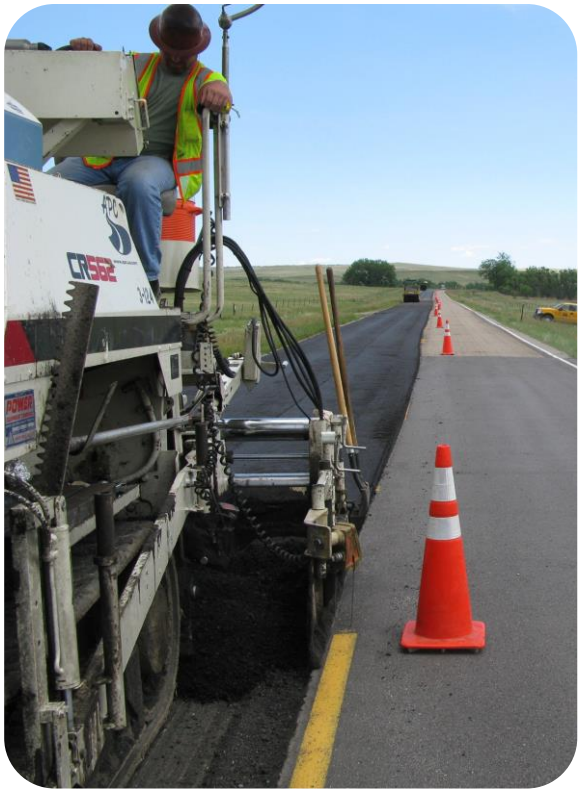
COLORADO
Department of Transportation





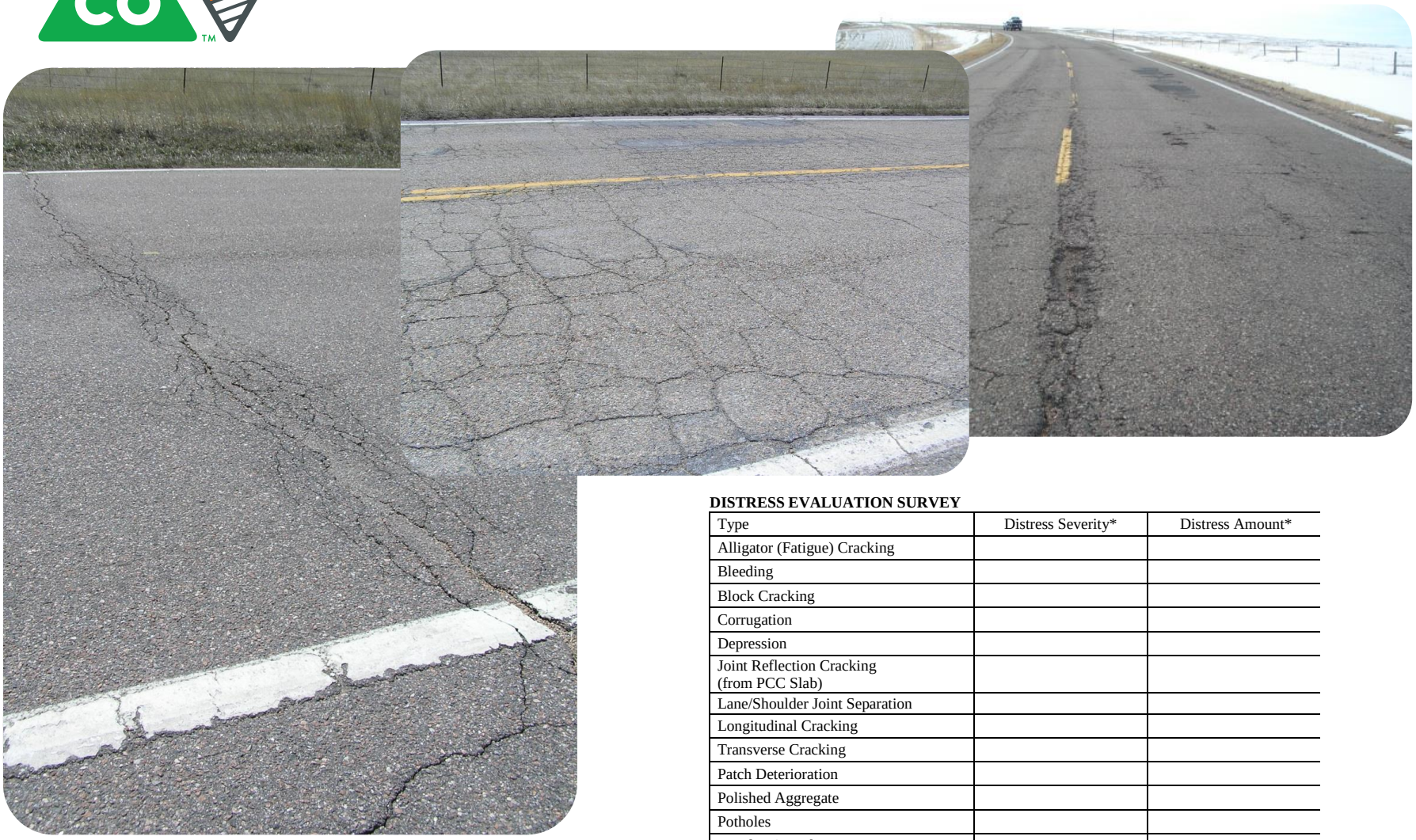
CDOT Cold In-Place Specifications and Construction

CIR Specifications and Construction

CDOT has successfully used CIR from the plains to the high mountains, and from low volume roadways to high volume interstates (+22K ADT)

1. Key Activities Before Construction
2. Key Specification Components
3. CIR Mix Design Considerations
4. Early Construction Activities
5. Avoiding Construction Surprises and Ensuring CIR Uniformity
6. Lessons Learned

Key Activities Before Construction



DISTRESS EVALUATION SURVEY

Type	Distress Severity*	Distress Amount*
Alligator (Fatigue) Cracking		
Bleeding		
Block Cracking		
Corrugation		
Depression		
Joint Reflection Cracking (from PCC Slab)		
Lane/Shoulder Joint Separation		
Longitudinal Cracking		
Transverse Cracking		
Patch Deterioration		
Polished Aggregate		
Potholes		
Raveling/Weathering		
Rutting		
Slippage Cracking		
OTHER		

Key Activities Before Construction

- Always locate and and quantify base failure areas.

- These should be repaired and patched prior to CIR work.

Key Activities Before Construction

5/17/10				Cores	Kiowa- East
MP	DIR	Depth	Dwpth	Comments	
23.7	WB	5"	5		
24.0	EB	5"	5		
24.4	WB	5 1/2"	5.5		
25.0	EB	4 3/4"	4.75		
25.5	WB	6 3/4"	6.75		
26.0	EB	6 1/2"	6.5	Broke at 5"	
26.5	WB	6 1/4"	6.25	Broke at 5.5"	
27.0	EB	6 3/4"	6.75		
27.5	WB	7"	7		
28.0	EB	6 1/2"	6.5		
28.5	WB	5 1/4"	5.25		
29.0	EB	7 1/2"	7.5	Broke at 3.5"	
29.5	WB	8"	8		
30	EB	10"	10		
30.5	WB	11"	11		
31	EB	8"	8		
31.5	WB	7 1/4"	7.15		
32	EB	6 1/2"	6.5		
32.5	WB	5 1/2"	5.5		
32.98	EB	9"	9	Broke at 7"	
			137.9		
	Average Thickness=		6.895		

Coring

for thickness

for weak layers

Soils for design

Key Activities Before Construction

Early Industry Engagement

Statewide Surface Treatment Projects for FY2014 - All baseline and RAMP projects

Shading used to show highway segments grouped into one project

Shading used to show highways lost in the redistricting effort

FY	Region	Highway	BMP	EMP	Description	Estimate	Treatment Type
2014	2	025A	50.0	59.0	25C INTERCHANGE TO JCT SH69 WALSENBURG NORTH	$12,257,499	2.5" mill and asphalt Overlay
2014	*2*	*025A*	*109.0*	*119.3*	*Pinon North*	*$15,174,000*	*FY14 RAMP - 2.5" mill and aphalt overlay*
2014	*3*	*070A*	*16.0*	*37.0*	*Loma to Clifton*	*$27,000,000*	*FY14 RAMP - 3" asphalt overlay*
2014	*3*	*070A*	*86.5*	*97.0*	*I-70 Rifle Slab Replacement*	*$4,000,000*	*FY14 RAMP - concrete slab replacement*
2014	3	070A	147.0	147.0	I-70 Eagle Interchange Improvements - Add to RPP project for paving only	$1,000,000	Add to RPP project for paving only
2014	3	070A	178.7	185.0	I-70 West Vail Pass	$2,200,000	2" asphalt mill and asphalt overlay of east-bound drive lane only - 14 ft wide
2014	*1*	*070A*	*203.9*	*213.5*	*I-70 EB Truck Lane*	*$2,000,000*	*FY 14 RAMP - 2" mill and asphalt overlay, right east-bound lane only*
2014	1	070A	213.5	217.0	EJMT Resurfacing	$2,500,000	Mill and stone matrix asphalt overlay
2014	4	076A	67.0	77.0	Slab replacements	$2,400,000	Concrete slab replacements, Advertised Accelerated project.
2014	*4*	*076A*	*149.0*	*165.5*	*NE COLO - Next I-76 Segment*	*$25,000,000*	*RAMP FUNDING FY14 - Major rehab not reconstruction*
					Interstate Baseline	*$20,357,499*	
					Interstate RAMP	*$73,174,000*	
2014	3	040A	129.9	131.7	US 40 Steamboat East and West		2" mill and and asphalt overlay (in town)
2014	3	040A	132.6	139.1		$6,000,000	2" asphalt overlay with spot leveling east of town
2014	6	040C	296.3	297.5	Colfax Ave., Federal to Speer	$2,000,000	2" mill and asphalt overlay
2014	3	050A	42.2	46.3	US 50 Whitewater East	$2,600,000	1.5" asphalt overlay, paving railroad approaches on SH 141
2014	2	050A	278.0	281.0	1ST ST TO Dozier Ave	$3,696,066	2.5" mill and modified asphalt overlay
2014	2	050B	377.4	381.2	THROUGH LA JUNTA	$5,211,329	2.5" mill and modified asphalt overlay
2014	6	088B	16.8	21.7	Arapahoe Rd - I-25 to Parker Rd	$9,000,000	2" mill and 2.5" stone matrix asphalt overlay
					50B THROUGH PUEBLO	drop $5,493,784	4" mill and 2" asphalt overlay plus 2" modified asphalt top surface
					36(Iris)	$400,000	Local Agency project, partnership to perform resurfacing on our roadway
						$12,000,000	**Full Depth Reclamation and 9.5" Concrete** or 6" Cold-In-Place Recycle with 3" Asphalt Overlay (CE Determination)
					o Florida	$9,500,000	2" mill and 2 - 2.5" aphalt overlay
					ores River Bridge	$8,500,000	Reconstruction south end and 1" asphalt leveling course plus 2" asphalt overlay north end
					to Towaoc (See 491A)	*$16,708,000*	*RAMP FUNDING FY14 - Full depth Reclamation with asphalt overlay*
					o (west of Wildcat Canyon)	$9,000,000	Determined after scoping
						$4,200,000	3" mill and asphalt overlay
						$1,000,000	Composite Asphalt over Concrete
					NHS - High Volume Baseline	*$73,107,395*	
					NHS - High Volume RAMP	*$16,708,000*	*(see 491A below also under this project: $19.708M RAMP total)*
						$6,500,000	Leveling course and overlay (scoping underway)
					ruction	$5,000,000	Concrete reconstruction
						$4,500,000	Leveling course and overlay (scoping underway)
					to Towaoc (See 160A)	*$3,000,000*	*RAMP FUNDING FY14 - 1" Leveling course 2" overlay*
					NHS - Medium Volume Baseline	*$16,000,000*	
					NHS - Medium Volume RAMP	*$3,000,000*	*(This segment constructed on same project with 160A above)*
						$3,500,000	1.5" overlay; mill and overlay where curb & gutter exist
						$12,500,000	6" Cold-in-Place Recycle with 4.5" asphalt overlay or 2" Mill and 2.5" asphalt overlay (CE Determination)
						$1,000,000	asphalt overlay
					to RPP project for minor ml paving only	$750,000	added to RPP project for minor mainline paving only
					million of FASTER funds for shoulders)	$9,500,000	Full Depth Reclamation with 3.25" asphalt overlay or 5" asphalt overlay (CE Determination)
					Other - High Volume Baseline	*$27,250,000*	
					Other - High Volume RAMP	*$0*	
						$7,400,000	2" mill and asphalt overlay
						$3,500,000	Thin asphalt overlay
						$500,000	Overlay and patching as needed
						$4,200,000	1.5" asphalt overlay
2014	1	103A	0.0	11.5	Jct I-70 - Jct SH 5	$5,000,000	Minimum of Mill and Asphalt Overlay

Key Specification Components

- Current “solventless emulsion” CIR specs since 2001
- Major effort by Region 3 yielded new specifications
- Now used in all regions
- Lime slurry required on all projects
- Latest specification has option to require CIR mix design performance criteria (improve durability, may allow thinner surface treatments.
  - Hamburg and Fracture Energy
- Have used with 2” and 1.5” overlay (SH71, US36)
- Future need for very thin wearing surfaces on CIR
  = low cost rehab option
  on treatment-restricted highways

< $5.40/SY-4”

Key Specification Components

- Email Bill for latest CDOT specs:bill.schiebel@state.co.us
- Recycled Material 90-100% passing 1” during production
- Mix Design required for Medium and Coarse gradations

	% Passing	
Sieve Size	Medium	Coarse
1.5”	100	100
1”	100	100
3/4”	85-96	75-92
No. 4	40-55	30-45
No. 30	4-14	1-7
No. 200	0-3	0-3

- 1.5% Hydrated Lime required all mixes
  - lime slurry with 30% solids minimum

Key Specification Components

ASPHALT EMULSION (CSS) (SPECIAL)

Test on Emulsion	Test Method	Minimum	Maximum
Residue from distillation, %	ASTM D244[1]	63.0	
Oil distillate by distillation, %	ASTM D244[1]		1.0
Sieve Test, %	ASTM D244[1]		0.3
Penetration (TBD[2]), 25°C, dmm	ASTM D5[3]	-25%	+25%

[1] Modified ASTM D244 procedure – distillation temperature of 177°C with a 20 minute hold. The ASTM D244 vacuum distillation procedure may be substituted once the maximum oil distillate is satisfied.

[2] TBD – to be determined by the Contractor's CIR design prior to emulsion manufacture for project. Penetration range will be determined on the design requirements for the project and will be submitted to the Region Materials Engineer for approval prior to project start.

[3] Modified ASTM D5 Procedure – The Penetration test for this material will be conducted under a dry condition with no water used on the surface of the emulsion residue.

ASPHALT EMULSION is paid for as separate bid item

Key Specification Components

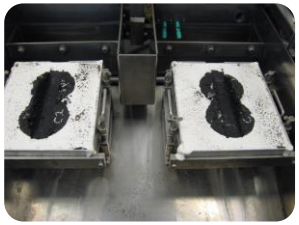
TEST	TEST PROCEDURE	MIX DESIGN REQUIREMENTS
Asphalt Content	CPL 5120	Report for Existing RAP at design.
Sieve Analysis	CP 31	100% Passing 1.25" Sieve – Report Target Gradations in Mix design.
Max. Sp. Gr. of Mix	CP 51	Report
Hveem Stability	CPL 5106 (25°C) as modified in CPL 5111	Report
Bulk Specific Gravity	CP 44 (AASHTO T-166)	Report
Air Voids	CPL 5115 **(30 Gyrations)**	8%-16% - Report Mix design target
Lottman Test	CPL 5109 as modified in CPL 5111 (30 Gyrations)	60% TSR for mix design with 1.5% Lime
Indirect Tensile Test	Modified Procedure Item (e) Above	–22ºC
Raveling Test	ASTM D7196 (10°C and 50% humidity)	2% max.
▲ **Additional** Requirements below **if direct loading** of CIR into paver hopper is required on the project		
Hamburg Wheel test on Medium and Coarse gradation	CPL 5112 (test at 50°C using 6" diameter 30-gyration compacted samples cured for 48 hours at 60°C)	5,000 passes min. with rut depth less than 12.5 mm
T_c, ºC, LTPPBind 3.1 for the single station closest to the project location	Report T_c, ºC	Determine T_c for the CIR Mid Layer Depth and 98% Reliability
Fracture Energy, J/m^2, ASTM D 7313, at T_c, Medium and Coarse Gradations and Corresponding Optimum Emulsion Contents	CIR Mixture Design Requirement For Cracking Resistance (**test** 6" diameter 30-gyration compacted samples cured for 48 hours at 60°C)	125 Minimum

Key Specification Components

- Required experienced field representative
  - documented “solventless” emulsion CIR experience
  - onsite first 3 days at minimum
  - minimum of three prior projects
- Pre-CIR Meeting required with prescribed agenda
- Daily contractor reporting requirements
- CIR Equipment Calibration requirements
  – Aggregates, Emulsion, and Lime Slurry
- Spreading and Placement equipment requirements
  – direct loading or windrow-pickup
- Compaction processes and requirements
  - 100% of T-180 sampled prior to breakdown roller
  - nuclear density measurement

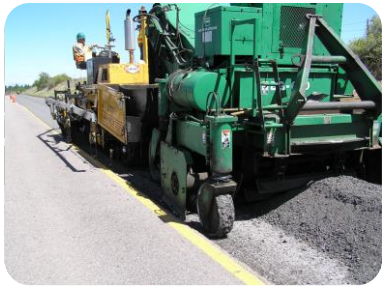
Mix Design Considerations

- Should You Add Mix Design Performance Requirements??




- Consider finished surface thickness
  - structural need
  - ADT and seasonal truck
  - heavy winter plowing


- Consider availability of contractors and their equipment capabilities




Mix Design Considerations

WESTEST
SPECIALISTS TO THE PAVING INDUSTRY

Client: [redacted]
Mix Design No.: [redacted]
Mix Design Method: Superpave

May 18, 2011

CDOT Grading:	Cold Bituminous Pavement Recycle Medium Gradation	Mixing Temperature:	75 °F
RAP Source:	Crushed Cores - US 36	Compaction Temperature:	75 °F
Emulsion Supplier:	[redacted]	Gyrations:	30
Emulsion Grade & Source:	CSS Special, Denver Terminal	Quicklime Supplier:	Chemical

EMULSION CONTENT DETERMINATION (CP-L 5111)

MIX PROPERTIES		LABORATORY TRIAL DATA			SPEC.	SUGGESTED STARTING POINT
EMULSION CONTENT (% BY WEIGHT OF MIX)		1.5	2.5	3.5		2.0
RESIDUE CONTENT (%)		0.98	1.63	2.28		1.30
THEORETICAL MAXIMUM SPECIFIC GRAVITY		2.374	2.354	2.334		2.364
THEORETICAL MAXIMUM DENSITY (PCF)		147.8	146.5	145.3		147.2
TEST DATA @ N_{DESIGN} GYRATIONS						
	BULK SPECIFIC GRAVITY	2.041	2.067	2.092		2.054
	DENSITY (PCF)	127.0	128.7	130.2		127.8
	% VOIDS IN TOTAL MIX	14.1	12.2	10.4	8-16	13.1
	HVEEM STABILITY	47	45	44		46
	**INDIRECT TENSILE TEST (° C), CRITICAL CRACKING TEMPERATURE				- 22 Min.	-32
	**RAVELING (%)				2 Max.	1.2
	**FRACTURE ENERGY (J/m²)				125 Min.	417.9
	**HAMBURG WHEEL TRACKING (mm), 5000 cycles, 50°C				12.5 Max.	9.7

MOISTURE SENSITIVITY TEST

LOTTMAN MOISTURE SENSITIVITY TEST RESULTS (CP-L 5109, METHOD B)					
AVERAGE DRY TENSILE STRENGTH (PSI)	33	38	41		36
AVERAGE CONDITIONED TENSILE STRENGTH (PSI)	23	26	28		25
TENSILE STRENGTH RATIO (%)	70	68	68	60 Min.	69
AVERAGE SPECIMEN VOIDS (%)	14.2	12.2	10.2		13.1
AVERAGE SATURATION (%)	76	75	76		76
QUICKLIME CONTENT (% BY WEIGHT OF RAP)	1.5	1.5	1.5	1.5	1.5
LIME SLURRY SOLIDS CONTENT (%)	30	30	30	30 Min.	30

** Testing preformed by PRI Asphalt Technologies, Inc.

Starting Construction

COLORADO DEPARTMENT OF TRANSPORTATION
PROJECT PRODUCED JOB MIX FORMULA

Project: STA0362-030
Location: US 36, WEST OF WATKINS TO BENN
Region: 01 Project Code (SA#): 17891

Mix Design: 05182011CIR1
Date: 5/18/2011
From Project No:
From Project SA#:

This Job Mix Formula defines the specified gradation, asphalt cement content, and admixture dosage for the grading and project shown.

Contractor: LaFarge
Supplier: Ballou Const. Co.
Plant: CIR Recycling Train Ballou
Pit: Existing US36 Recycled Material
Grading & Compaction: CIP MEDIUM 30 CIR
% RAP: 100.00 % Lime: 1.50

Components:
1. 100 CIR Roadway Millings
2. with 1.5% Lime Solids by slurry
3. and 2.25% CSS-Special to Start
4.
5. Gradation Range base on Lafarge
6. CIR Mix Design - Medium Gradation
7. Voids Range by spec 8% to 16%
8. Hveem for Info Only

Remarks: Form#43 to set initial emulsion field targets. Adjustments will occur per contractor input. 30 Gyration in Lab.

Gradation (% Passing)

☒ Specification ☐ Voids Acceptance

Seive mm (in)	% Pass Min	% Pass Max
37.5 (1 1/2):		
25.0 (1):		
19.0 (3/4):	85	96
12.5 (1/2):		
9.5 (3/8):		
4.75 - #4:	40	55
2.36 - #8:		
1.18 - #16:		
600 mic - #30:	4	14
300 mic - #50:		
150 mic - #100:		
75 mic - #200:	.00	3.00

Property	Voids Data at Nds Target Value	Tolerance
Stability	44	Minimum
% Voids	12.70	+/- 4.0
~~% VMA~~	min .0	max 1.0
~~% VFA~~	min 1	max 2

% AC: 2.25 +/- .2
Grade of AC: ~~CSS-1P~~ Special
Source of AC: SUNCOR
Max. Sp. Gr. at % AC: 2.359 +/- .01
Bulk Sp. Gr. of Combined Agg: .000
Bulk Sp. Gr. of Fine Agg: .000
Angularity (T 304): .0
% Agg Absorp (SSD): 0

☐ New Mix Design With Changes
☐ Mix Design Modified
☒ New Mix design with no change

Signed _____ Date _____
Project Engineer: Johnson, Brock

Signed William R Schiebel Date 5/18/11
Regional Materials Engineer: Schiebel, Bill

Distribution:
Staff Materials

- Project Production Targets are set
- Emulsion %
- Voids
- Gradation Band

Early Construction Activities

- Thorough, documented equipment calibration
- Agenda-driven pre-CIR Meeting is a must
- Set ground rules and decision making process

- ❑ Equipment Specs
- ❑ Personnel/Contacts
- ❑ CIR expert name/cred
- ❑ Contractor CIR process
- ❑ Weather contingency
- ❑ QC/QA names/process
- ❑ Mix Design details
- ❑ Field adjustment who and how
- ❑ Opening to Traffic plan

CIR Construction – a 3 minute video

Avoiding Surprises and Ensuring CIR Uniformity

- Design Plans should include useful field data:
  - Coring data showing thin pavement sections
  - Note and repair base failure areas pre-CIR
- Identify important changes in existing pavement

  (maintenance overlays, chipseal, crackseal)
- Empower qualified on-site field staff
  - daily emulsion and production rate changes
  - direct communication to emulsion supplier
  - compaction control and changes
- Routine Open Communication – all parties

Avoiding Surprises and Ensuring CIR Uniformity

- Field Adjustments will be necessary
  - due to gradation changes or other changes
- +/- 0.2% without approval on emulsion content
- Field testing for density and gradation.
  Pavement Moisture:
  (overlay when <1% “free” moisture)

Sieve Size	% Passing	% Emulsion From Table
1"	100	0.02
#4	42	0.04
#8	28	0.09
#16	12	0.16
#30	7	1.82
	Total	2.1

Field Table for calculating emulsion content based on field gradation

										Emulsion by sieve
1 inch	100									
	0.02									
No. 4	34	36	38	40	42	44	46	48	50	52
	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.06
No. 8	18	20	22	24	26	28	30	32	34	36
	0.07	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.11	0.12
No. 16	6	8	10	12	14	16	18	20	22	24
	0.11	0.13	0.14	0.16	0.17	0.19	0.20	0.21	0.23	0.24
No. 30	2	3	4	5	6	7	8	9	10	11
	0.96	1.13	1.30	1.48	1.65	1.82	1.99	2.16	2.34	2.51
Total										

Avoiding Surprises and Ensuring CIR Uniformity

- Field Adjustments will be necessary
  - due to pavement changes
  - due to test results

Project Loc.:	US 36, West of Watkins to Bennett											
SA#:	17891											
Grading:	CIP Medium Gradation											
Form #43 No.:	05182011CIR1											
Lab#	11-18	11-24	11-22	11-27	11-28	11-34	11-40	11-44	11-43	11-46	11-52	
Field Sheet#	6619	6620	6576	6579	6578	6621	6622	6623	6624	6580	6585	
Sample Date	6/3/11	6/6/11	6/7/11	6/9/11	6/10/11	6/13/11	6/14/11	6/15/11	6/16/11	6/17/11		
Rec. Date	6/6/11	6/6/11	6/7/11	6/13/11	6/13/11	6/14/11	6/16/11	6/16/11	6/17/11	6/21/11	6/27/11	
Rec. Time	8:00 AM	10:00 AM	2:15 PM	11:00 AM	11:00 AM	2:30 PM	9:00 AM	9:00 AM	10:50 AM	12:20 PM	7:00 AM	
Sample#	1	N/A	2	3	4	5	6	7	8	9	10	#43 Spec
Rice	2.336	2.339	2.298	2.350	2.352	2.347	2.357	2.353	2.368	2.369	2.353	2.349 - 2.369
Bulk	2.033	*2.010	2.063	1.995	2.032	2.046	2.129	2.111	2.091	1.992	2.041	
AV	13.0	*14.1	10.2	15.1	13.6	12.8	9.7	10.3	11.7	15.9	13.3	8.7 - 16.7
Stability	15	N/A	13	17	16	27	20	22	15	14	18	Info
TSR Wet Str	18.0	-	16.5	18.5	18.2	23.1	22.3	21.1	10.1	18.9	21.6	
TSR Dry Str	28.7	-	29.9	27.2	25.2	37.3	33.2	30.1	15.5	30.9	31.7	
Tensile Str Ratio	63	-	55	68	72	62	67	70	65	61	68	60 Min
Hamburg		- 12.74 mm @ 2715 Passes (avg)						-13.60mm @ 4915 passes				12.0 mm (Max) @ 5000 Passes
Uncorrected Burn AC for Info:		2.25% Target Emulsion Rate										
	8.13%											

CIR Colorado Lessons Learned

- Lime Slurry works for us
- Early compaction test sections help dial in the mix
- Specify equipment capabilities and calibration
- Require and set agenda for Pre-CIR Meetings
- Require and empower experienced contractor
- Density is crucial, but cracking is worse
- Confined edges help in narrow roadways
- Performance tests best on FMFC samples (cores)
- Compact lab gyratory samples ASAP after sampling
- Grind CIR for smoothness if thin surfacing used
- Heavy Tack Coat prior to surfacing (0.2 to 0.3 gal/SY)

CIR Colorado Lessons Learned

Confined edges help on narrow roadways

CIR a Solid Pavement If Done Right

Thank You

Questions???