Chapter 11
Bonded Wearing Course

From… Maintenance Technical Advisory Guide (MTAG)

Managers' Overview

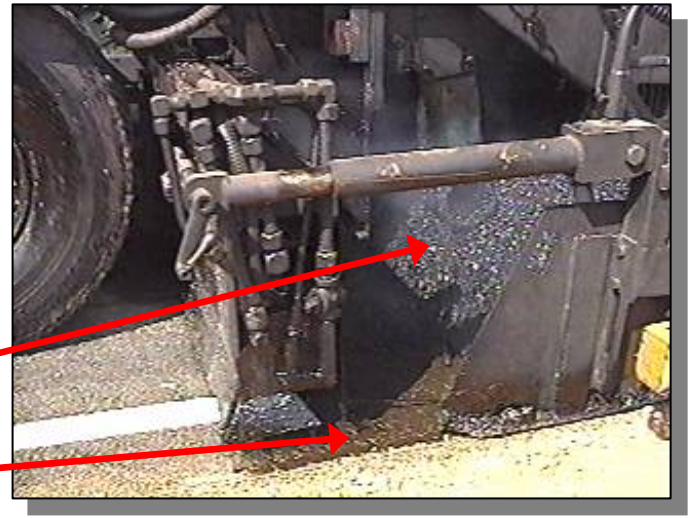
From… Maintenance Technical Advisory Guide (MTAG)

Bonded Wearing Course (BWC)

- What is BWC ?
- Why use BWC?
- When to use BWC?
- Where to use BWC?

District 7 Rt. 66, BWC Gap Graded, Constructed in 2005

What is BWC?



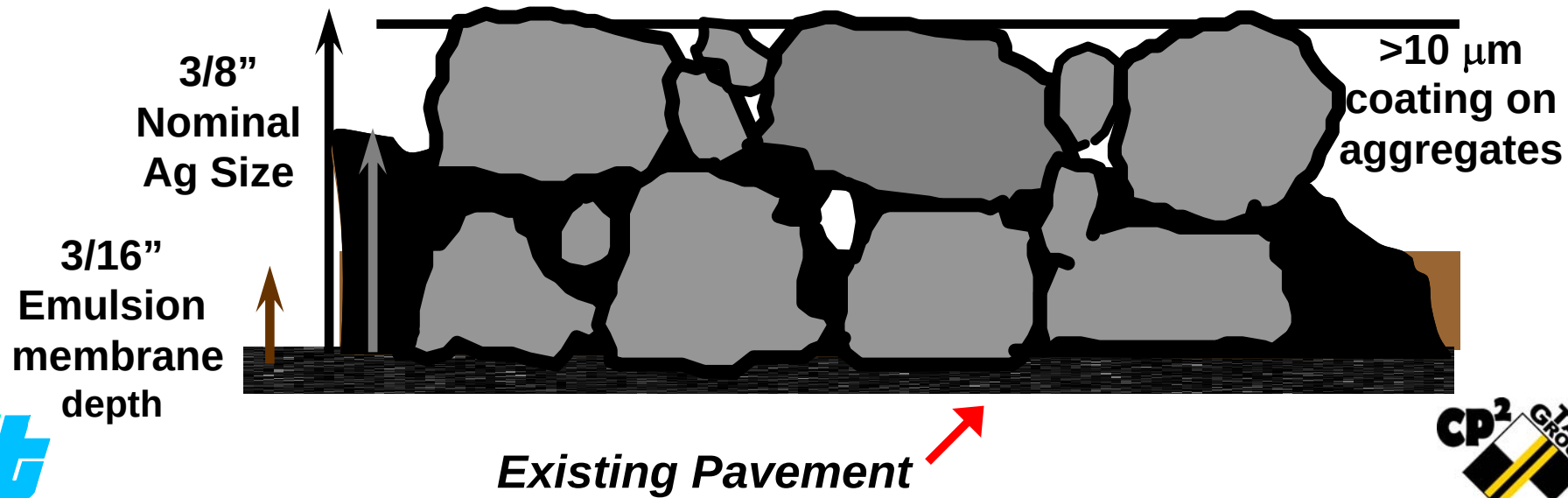
- **A thin, Hot Mix Asphalt Overlay placed over a polymer modified emulsion membrane which:**
  - **seals the existing pavement**
  - **bonds the two surfaces**
- **The roadway is open to traffic very quickly**
- **This process is done in a single machine**

What is BWC?

Emulsion membrane "wicks up" around the HMA aggregates

The emulsion cures, bonding the mix & pavement

3/4" Typical Mix Depth



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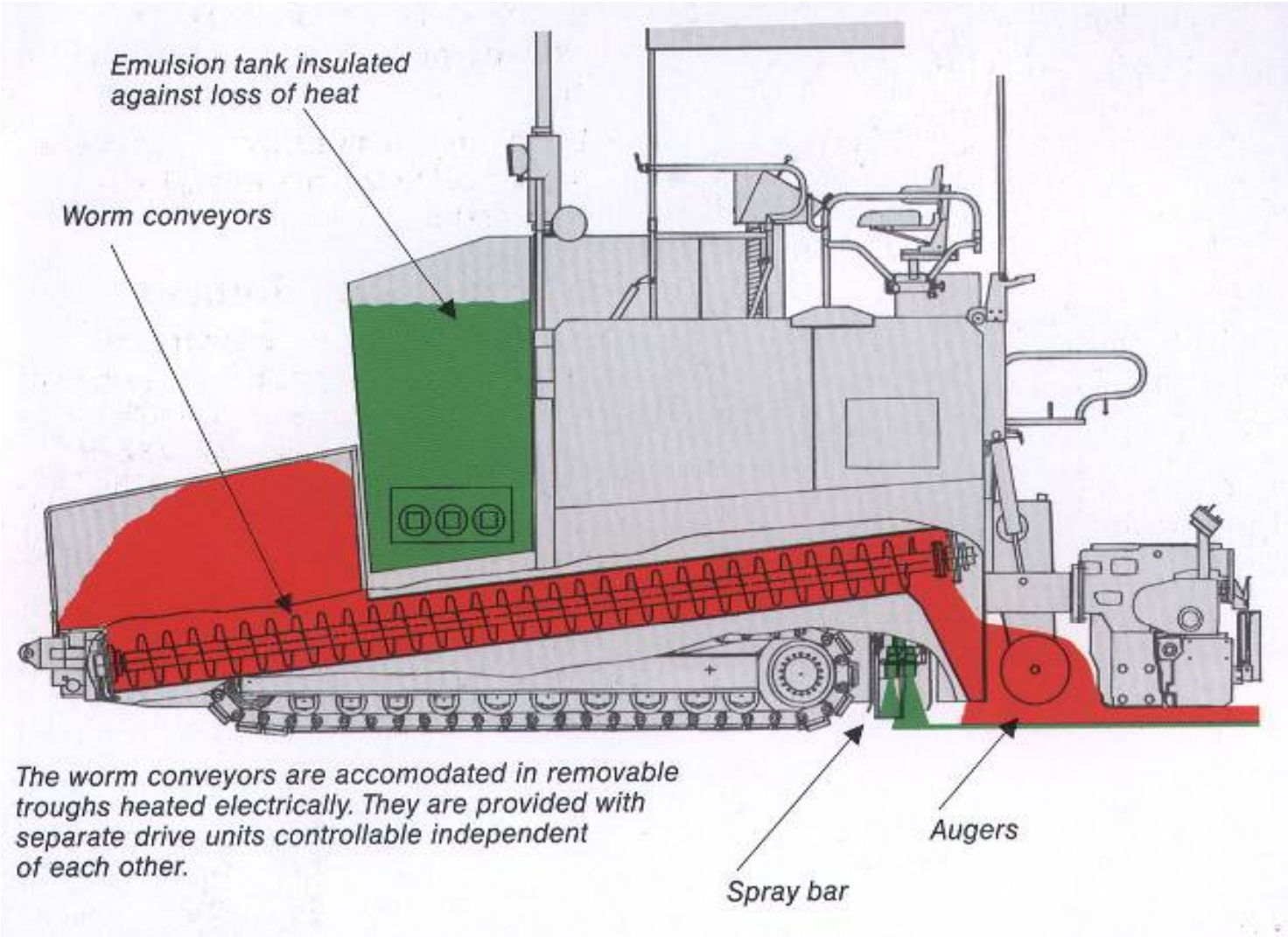
BWC Specification

- SSP 39-700
  - Modified PG binder
  - Gap Graded
- SSP 39-701
  - Asphalt binder
  - Gap Graded
- SSP 39-702
  - Modified PG or asphalt rubber
  - Open graded
- High quality aggregate
  - Restores & retains friction
- Mix designed specially for process

BWC Specification



Single machine applies polymer modified emulsion membrane and HMA!

Why use BWC?

12+ year old surface
US 281, TX

Performance

9 years after paving

Lark Ellen LA County 12/2007

Why use BWC?

Construction Speed and Quick Return to Traffic (7- 15 minutes for PM binders)

Front Street in Sacramento
May 15, 2003

When to Use?

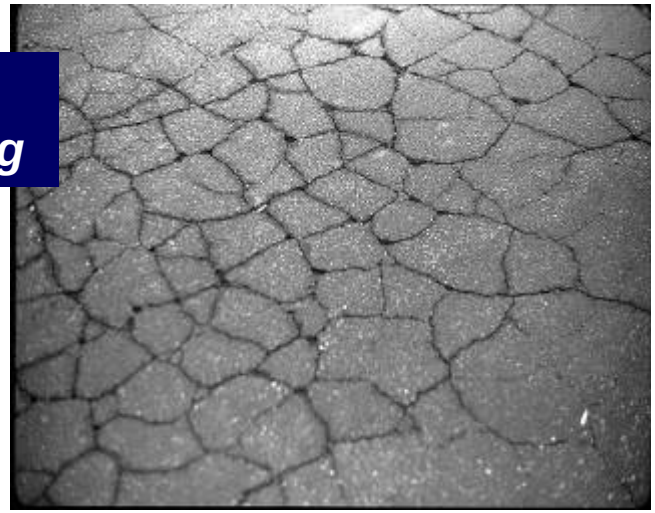
Site Selection Guidelines

- Structurally sound pavement
- Rut depth < 1/2”
- Minor to moderate transverse & longitudinal cracking
- Bleeding minor to moderate
- Raveled

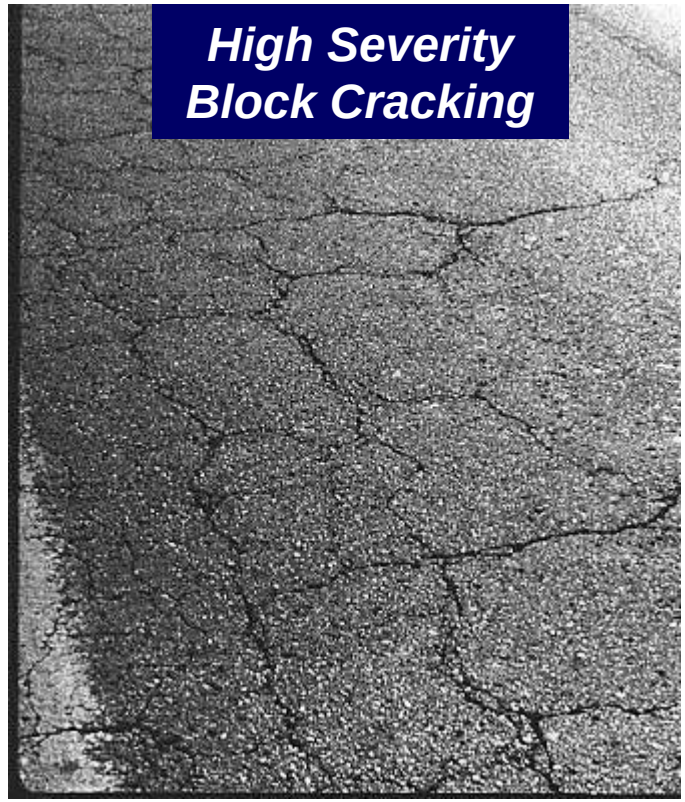
When NOT to Use!

Poor Candidates

High Severity Alligator Cracking



High Severity Block Cracking



Rutting >1/2”

High Severity “D” Cracking

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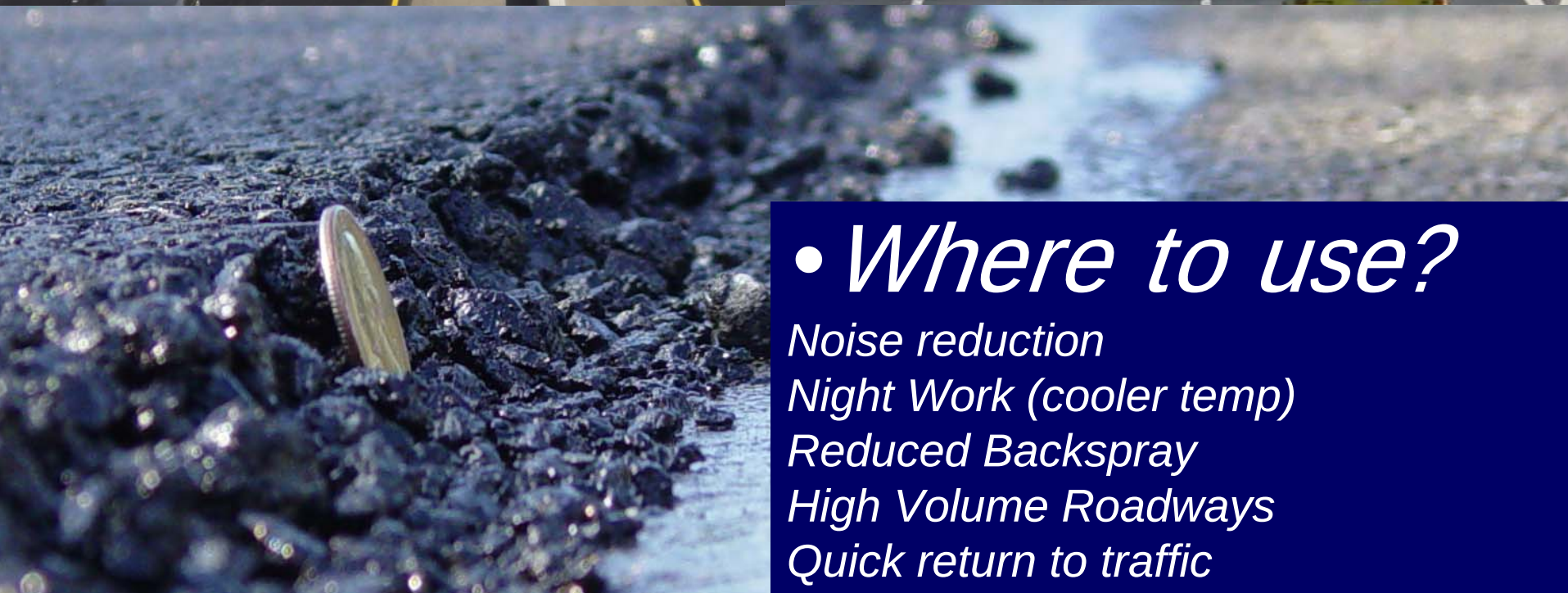
Where/Why to Use (cont.)

- Quick return to traffic- Reduced Work Zone Time → *Workers' Safety*
- Noise Reduction- Open/Gap Graded Mix
- Night Work → *More working days*
  - Placement temps as low as 45°F for polymer modified binders
- Reduced Backspray- Open/Gap Graded Mix
- High Volume Roadways- Faster Paving Process → *Get In- Get Out*



- *Where to use?*

Noise reduction
Night Work (cooler temp)
Reduced Backspray
High Volume Roadways
Quick return to traffic

Bonded Wearing Course Training Modules Available

1. Design, Materials & Specifications
2. Construction & Inspection

Module 11-1

Design, Materials & Specifications

From… Maintenance Technical Advisory Guide (MTAG)

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Topics to be covered

- **Project Selection**
  - **Distress and Other Application Considerations**
  - **Performance**
  - **Cost**
- **Design Considerations**
  - **Mobilization**
  - **Typical Materials Items**
  - **Quantity Calculations**
  - **Production Rates**
    - **Roadway Widths**
    - **Roadway Geometry**
  - **Traffic Control**
  - **Miscellaneous Items**
  - **Sample Project**
- **Materials and Specifications (including SSP's)**
- **Summary**

Project Selection

- Distress and Application Considerations
- Performance

Factors to Consider When Choosing a Maintenance Treatment

- Will the treatment address the distresses present? (i.e., Will it work?)
- Can the required preparation for the treatment be carried out?
- Is the treatment affordable and cost effective?
- Will the treatment be performed before the situation being addressed changes?

Three Basic Steps In The Selection Process

1. Assess the existing conditions.
2. Determine the feasible treatment options.
3. Analyze and compare the feasible options with each other.

Initial Site Assessment Distress Identification

- Types of Distresses and Definitions
- Definitions from:
  - “Guide to the Investigation and Remediation of Distress in Flexible Pavements,” Caltrans, July 2003
  - “Distress Identification Manual for the Long-Term Pavement Performance Program,” FHWA, June 2003

Distress Types and Levels that can be addressed by BWC

- Perform Visual Site Inspection.
  - Identify types, quantity and levels of distress
  - For example on a 2 lane highway (Route xxx from PM 0.0 to PM 10.8) with <30,000 ADT:
    - **10% Alligator B Cracking**
    - **Minor Transverse Cracking**
    - **An area of isolated base failure 1000 ft x 4 ft**
    - **Heavy raveling and oxidation**
    - **Rutting < ½”**

DISTRESS AND APPLICATION CONSIDERATIONS

Pavement Type	Cracking	Patching/ Potholes	Surface Deformation	Surface Defects	Joint Deficiencies
AC	1. Longitudinal & Transverse (Medium) 2. Block (Moderate) 3. Edge (Moderate)	Patches: Moderate Potholes: Moderate	Rutting: <0.5 in Shoving: No	Bleeding Moderate Polished Agg: OK Raveling: Severe	N/A
PCC	1. Corner Breaks (Moderate) 2. Materials Related Distress (Low) 3. Longitudinal (Moderate) 4. Transverse (Moderate)	N/A	Studded tire or chain wear (Low)	Map cracking and scaling: < 12 yd^2 to 120 yd^2	Spalling: Moderate
Note: For PCC, a BWC will not treat blowups, pumping, faulting of joints, or crack widths > 3/8 in					

BWC is a viable application for treating structurally sound, worn pavements

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Other Application Considerations

- **Traffic control**
- **Safety**
- **Night work**
- **Returns/hand work (NO SETBACKS)**
- **Turn pockets**
- **Milling**
- **Job quantities**
- **Prep work required**
- **Quick return to traffic- reduced work zone time *(Workers' Safety)***
- **Noise reduction- open/gap graded Mix**
- **Night work- min temp 45º F *(More working days)***
- **Reduced Backspray- open/gap graded mix**
- **High volume roadways- faster paving process (*Get In- Get Out)***

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Expected Life

- Projects placed in 1993 and 1994 in Pennsylvania, Texas and Louisiana, are still performing well
- County of LA placed first project in CA in 1998
  - Exceeding the County's expectations
  - No delamination
  - No maintenance activities have been required on the BWC section of roadway for the past 9 years.

12+ year old surface
US 281, TX

Lark Ellen
LA County
9 year old surface

Skid Resistance

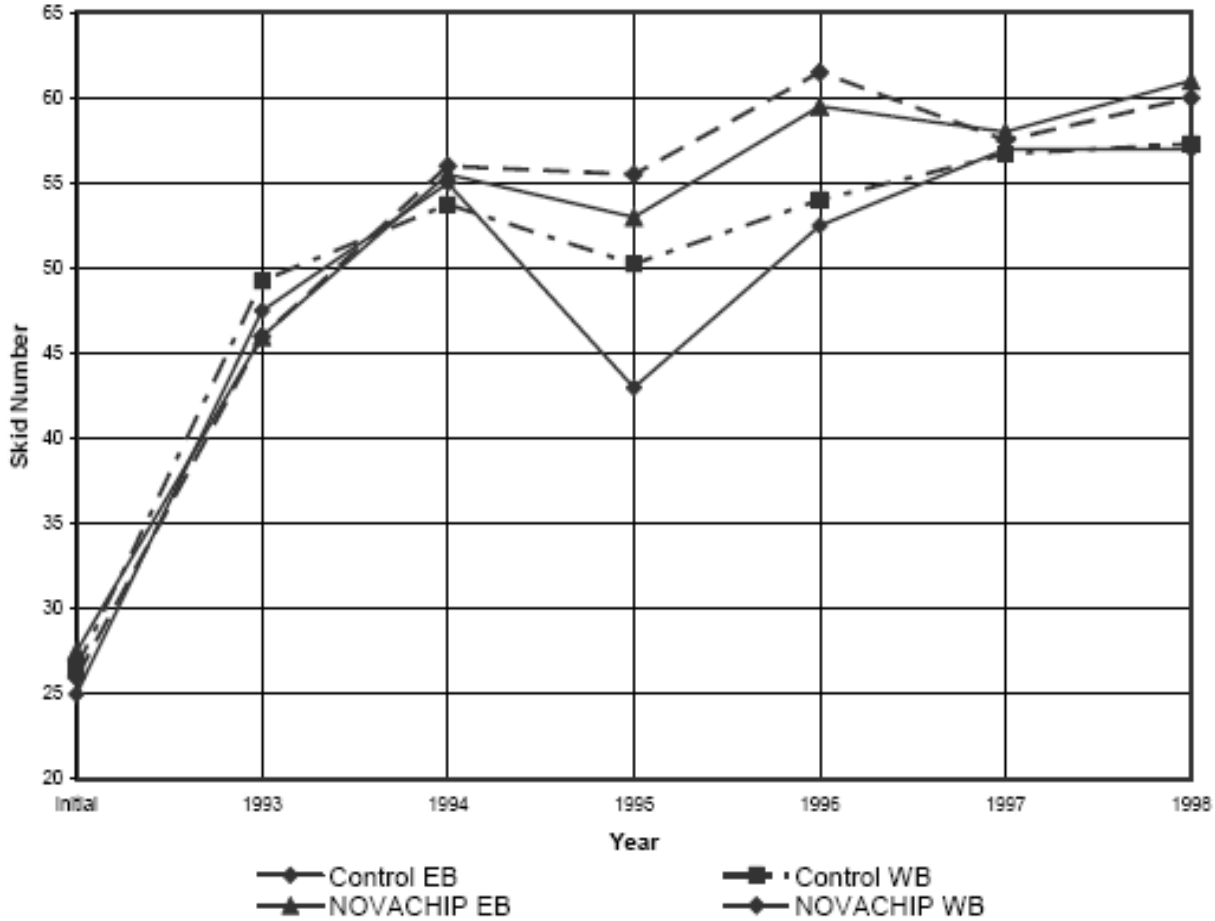
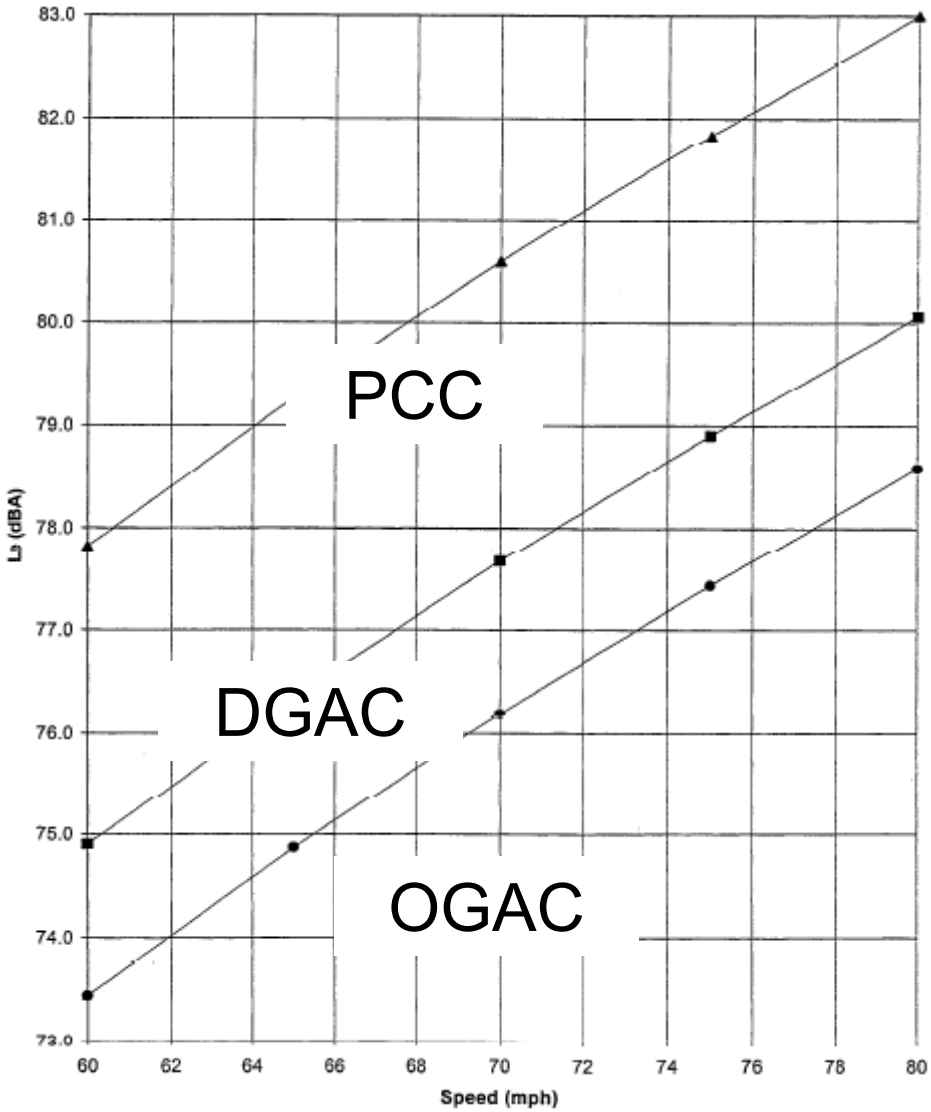


Figure 1: Change in Skid Resistance Over Time (5)

Noise Reduction Data



Data from Acentech Route 85 Noise Mitigation Study Report No. 184 Dated: January 1998

Note: OGAC was the designation for BWC in this study

Spray Reduction

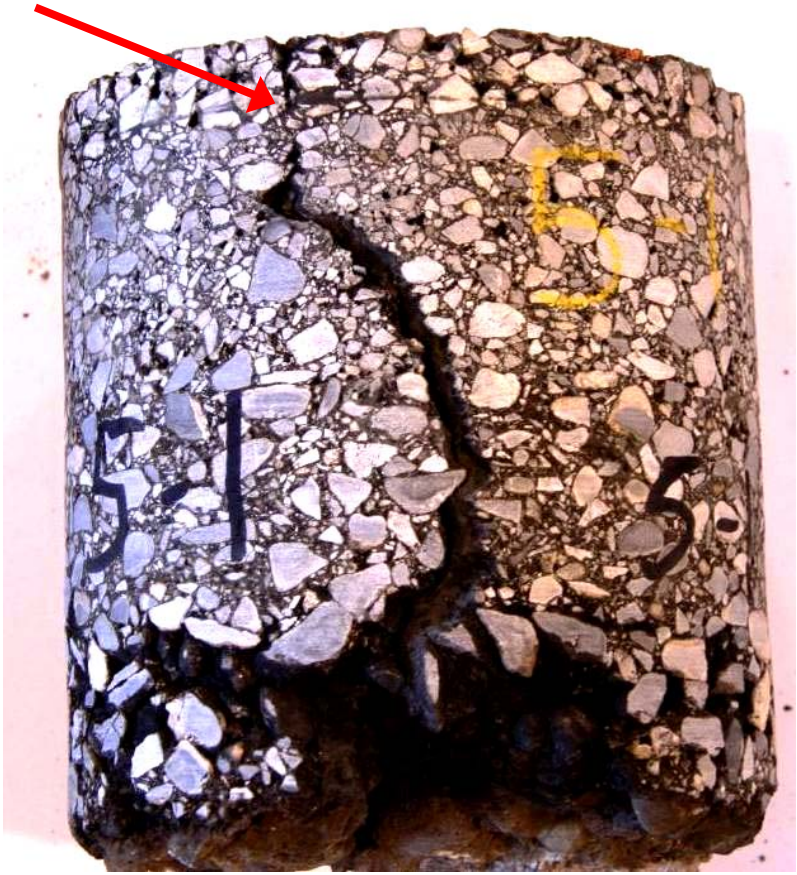
Table 8: Hydraulic Conductivity as an Indication of Spray Reduction Characteristics (4)	
Material	**Hydraulic Conductivity (s^{-1})**
14 mm SMA	0.03
12.5 mm BWC Type G	0.06
10 mm UL-M	0.01
12.5 mm OGAC	0.12

Improved Ride Quality - (Smoothness)

- Minor ruts and depressions can be filled with BWC to improve ride quality

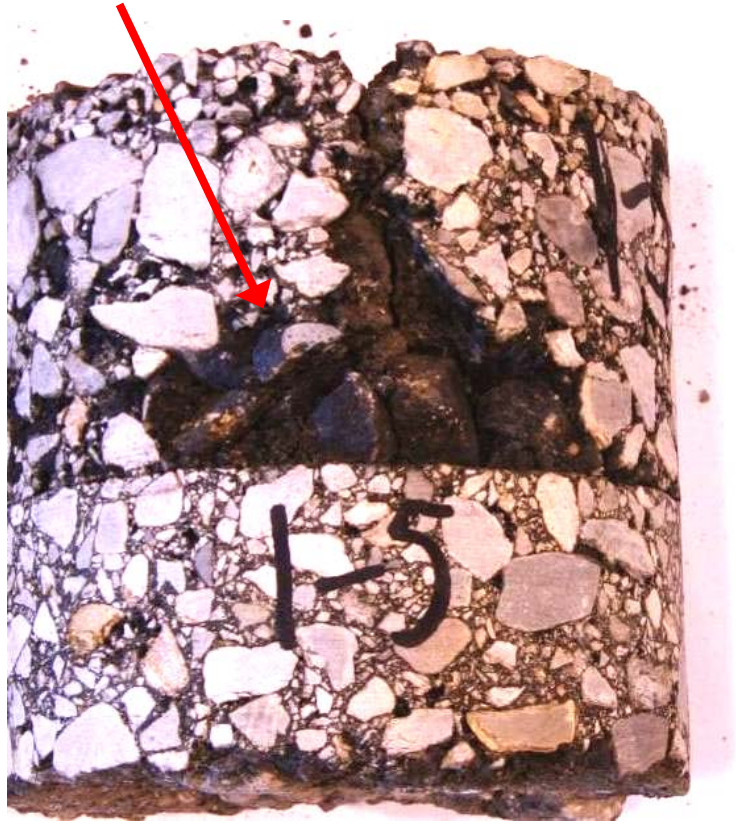
Impact on Reflective Cracking

Sealed at membrane



BWC Surface

V shaped, indicative of raveling



OGFC Surface

Future Considerations

- The main method of failure is wear; the surface oxidizes and is abraded
- Future PM applications may include:
  - Fog Seal
  - Microsurfacing
  - Additional BWC Application
  - Cold in-Place Recycling
  - Mill and Replace
  - Crack Sealing
  - Patching
  - Re-Striping

Cost

- In 2007, BWC total project prices averaged $12 per square yard with the range being between $9 and $14.
- High end of this range was seen on projects with limited work windows due to the influence on production and the thin application of the HMA.
- Other factors that influence costs for BWC projects include; materials used, night work vs. day work, quantities, lime treated aggregates, size of project, trucking, and the project location.

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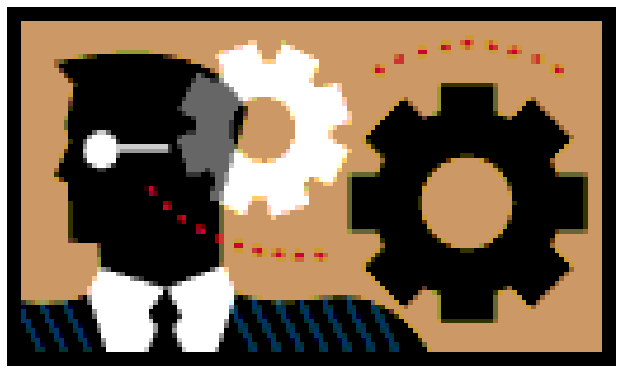
Design Considerations

- Mobilization
- Typical Materials Items
- Quantity Calculations
- Production Rates
  - Roadway Widths
  - Roadway Geometry
- Traffic Control
- Miscellaneous Items
- Sample Project



Mobilization

- Similar to Typical Asphalt Paving
- On-site Staging Required –
  - Area for Tanker and Distributor exchange
- Special Permitting - None

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Typical Materials Items

- Asphalt Concrete Tons
  - Use maximum lbs/SY for selected aggregate size
    - **3/8” max = 85 lbs/SY**
    - **1/2” max = 100 lbs/SY**
- Emulsion Tons
  - Use 0.2 gallons/SY for emulsion application
  - Varies with mix types (0.13-0.30 Gal/SY)

Quantity Calculations

- When calculating quantities for each application use highest application rate per SY for estimate purposes
  - Example:
    - Specification 37-1.06 Spreading of screenings for chip seal application. Range is 12-20 lb per SY. ***Use 20 lb for estimating quantities***

Example of Actual BWC Calculation

- Typical 2 Lane Roadway 1 mile long with 3 foot shoulders = 17,600 SY
- 10 mile section of roadway = 176,000 SY
- AC Tons for Type B (3/8”):
  - **176,000 SY X 95 lbs/SY / 2000 lb = 8,360 Total AC Tons**
- Emulsion Tons
  - **176,000 x 0.2 GAL/SY / 240 Gal/Ton = 147 Tons of Emulsion**

Production Rates and Paving Days

- Production Rate
  - Mainline Paving - 125 tons per hour
  - Returns/Turnpockets - 20-50 tons per hour
- (# of Paving Days)
  - Minimum 5 days to make cost effective

Roadway Geometry and Widths

- Urban
  - Milling
    - ¾ - 1” contour edge grind required to match curb and gutter and existing pavement
  - Drainage
    - Minimal water trapped against curb due to emulsion filling void structure and thin lift
    - Less water intrusion to pavement interface due to emulsion membrane

Roadway Geometry and Widths


Shoulder backing machine

- **Rural**
  - **Cross-slopes**
  - **Shoulder**
    - **For grade differential > 3% from mainline to shoulder, pave shoulder separately (shoulder backing machine)**
    - **Edge drop-off < ¾” (consider bicycle traffic, material can not be feather down lower then top size agg.)**
    - **In contrast to standard paving, pave shoulders and turn-pockets first and through lanes last. (Note to RE file)**
  - **Varying Width**
    - **Typical Paving machine width 8-14 feet variable**

Traffic Control

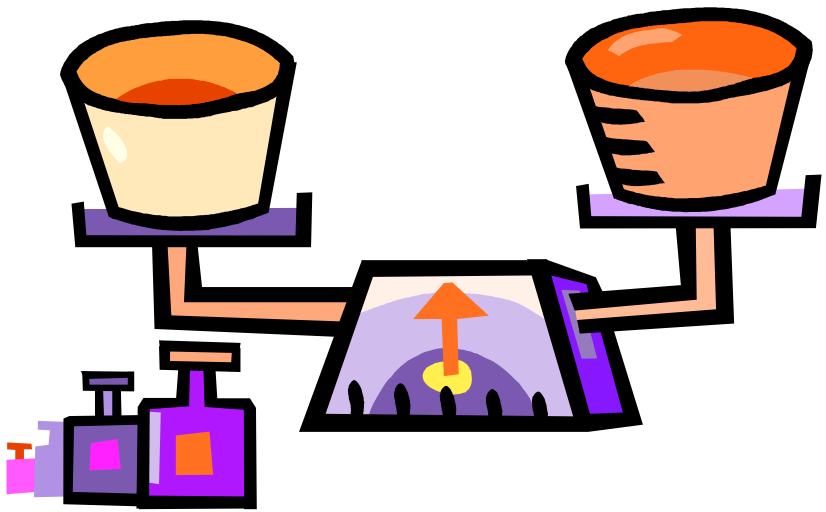
- Typical release to traffic:
  - 10-20 minutes behind paver for polymer modified binders
  - 20 – 30 minutes for rubberized binders (require sanding)
- Multi-lane highways, consider moving lane closure
- Two-lane roadways ½ to ¾ mile closure
- Thinner lift allows faster production
- Emulsion membrane eliminates need for Tack Coat

Miscellaneous Items

- Edge grinding
- Crack seal hot applied min one month prior
- Patching - hot mix only, cold mix continues to rut
- Utilities – Adjustments most likely necessary
- Loops may need to be replaced if doing edge grinding
- Dig outs – Prior to paving
- Signing and Striping

Sample Design Example

- Item codes
- Item descriptions
- Unit of measure



Item code

- Caltrans uses item codes along with estimated item quantities to develop project construction costs.
- An item code is a six digit code used to describe a specific item or activity in a project.
- For example,
  - the item code 193118 is used for concrete backfill and the item code 066074 is used for traffic control.
  - Each item code has a unit of measure. Concrete backfill is measured in cubic yards and traffic control is a lump sum unit.
- The engineer must determine what work items and/or activities are expected in the project and develop estimated quantities for bidding purpose. Caltrans Standard Materials and Supplemental Work Item Codes can be found at the following web site: http://i80.dot.ca.gov/hq/esc/oe/awards/#item_code.

Example of Item Codes

Item Code	Description
120090	Construction area signs
120100	Traffic control system
128650	Potable changeable message sign
413111	Repair spalled joints
413114	Replace joint seal (existing concrete pavements)
413115	Seal joint (existing concrete pavements)
414091	Seal longitudinal joint
414101	Seal transverse joint
414111	Rout and seal random cracks

Example of Item Codes required to place Polymer Modified Open Graded 3/8” Mix Project in District 1

01-442304
01-HUM-299
08/29/06

ITEM NO.		ITEM CODE	ITEM DESCRIPTION	UNIT OF MEASURE
1		070020	WARRANTY	LS
2		074017	PREPARE WATER POLLUTION CONTROL PROGRAM	LS
3		074020	WATER POLLUTION CONTROL	LS
4	(S)	120090	CONSTRUCTION AREA SIGNS	LS
5	(S)	120100	TRAFFIC CONTROL SYSTEM	LS
6	(S)	128650	PORTABLE CHANGEABLE MESSAGE SIGN	EA
7	(S)	150715	REMOVE THERMOPLASTIC PAVEMENT MARKING	M2
8	(S)	153103	COLD PLANE ASPHALT CONCRETE PAVEMENT	M2
9		198007	IMPORTED MATERIAL (SHOULDER BACKING)	TONN
10		374492	ASPHALTIC EMULSION (POLYMER MODIFIED)	TONN
11		039925	ASPHALT CONCRETE (OPEN GRADED, 9.5 MM MAXIMUM GRADING)	TONN
12	(S)	840515	THERMOPLASTIC PAVEMENT MARKING	M2
13	(S)	840561	100 MM THERMOPLASTIC TRAFFIC STRIPE	M
14	(S)	840568	100 MM THERMOPLASTIC TRAFFIC STRIPE (BROKEN 3.66 M - 0.92 M)	M
15	(S)	840570	100 MM THERMOPLASTIC TRAFFIC STRIPE (BROKEN 10.98 M - 3.66 M)	M
16	(S)	850122	PAVEMENT MARKER (RETROREFLECTIVE-RECESSED)	EA

Material Specifications

- 3 specifications
  - SSP 39-700 – BWC Type G
  - SSP 39-701 – RBWC Type G
  - SSP 39-702 – BWC Type O and RBWC Type O
- Each differ in binder, aggregate, and mix design procedure
- Polymer modified emulsion membrane is the same for all

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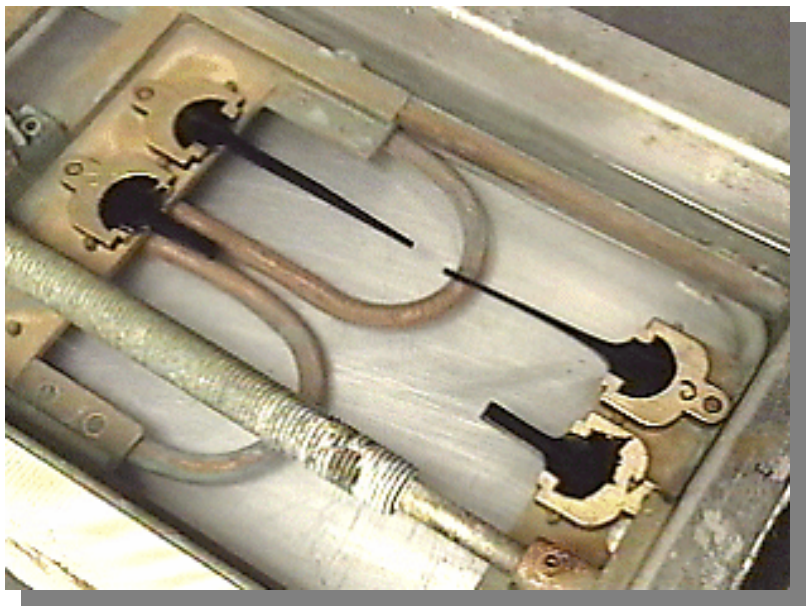
PG Binders

Binder Grades used in Pavement Climatic Regions for BWC Type G	
Climatic Region	**PG Binder Grade**
Desert	PG 76-22PM
South Coast Central Coast Inland Valleys North Coast Low Mountain South Mountain High Mountain High Desert	PG 64-28PM*

Note: (*) Use PG76-22PM on routes with 20 year ESAL's greater than 10 million (or TI of 12) and where slow moving standing traffic is expected

PG Binders

- BWC – O
  - PG 58-34PM for all project regardless of location



Asphalt Rubber Binders

- The binder for RBWC – G and RBWC – O is identical to RHMA – G of Section 39 of the Standard Specifications
- The recommended base stock is based on DIB 86.
- RBWC only recommended in area of CA that frequently place RHMA.

Climatic Region	Base Stock for Rubberized Asphalt
South Coast Central Coast Inland Valleys North Coast Low Mountain South Mountain Desert	PG 64-16
High Mountain High Desert	PG 58-22

Aggregate Gradation Selection

	Gradation		
Characteristics	**1/2”**	**3/8”**	**No. 4 (A)**
Minimum Lift Thickness	1”	3/4”	5/8”
High Traffic	Excellent	Excellent	Good
City Streets	Excellent	Excellent	Excellent
Residential Streets	Good	Excellent	Excellent
Bicycle Traffic	Fair	Good	Excellent
Pedestrian Traffic	Fair	Good	Excellent
Noise Mitigation	Fair	Good	Excellent
Reflective Cracking Mitigation	Excellent	Good	Fair
Release to Traffic	Excellent	Excellent	Excellent

Note (A): No. 4 gradation only applies to BWC Type G mix

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Other Considerations

- In mountainess environments with multiple daily freeze thaw cycles, use only BWC or RBWC Type G.
  - Modification to the BWC Type G gradations for this climate is in SSP
- BWC or RBWC Type O recommended for areas with frequent or heavy rainfall.
  - Open texture allows more water to be removed from road surface.

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Aggregate Gradation

(Percentage Passing)

Bonded Wearing Course – Gap Graded

3/8–inch HMA

Sieve Sizes	Target Value Limits	Allowable Tolerance
1/2"	100	-
3/8"	80 - 100	TV ±6
No. 4	25 - 40	TV ±7
No. 8	19 - 32	TV ±6
No. 16	16 - 22	TV ±5
No. 30	10 - 18	TV ±5
No. 50	8 - 13	TV ±4
No. 100	6 - 10	TV ±2
No. 200	2 - 6	TV ±2

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Aggregate Quality		
Quality Characteristic	Test Method	Requirement
Percent of crushed particles Coarse aggregate (% min.) Two fractured faces Fine aggregate (% min) (Passing No. 4 sieve and retained on No. 8 sieve.)	CT 205	90 85
Los Angeles Rattler (% Max.) Loss at 100 Rev. Loss at 500 Rev.	CT 211	12 35
Sand equivalent [a] (min.)	CT 217	47
Cleanness value [b] (min.)	CT 227	57
Plasticity Index (max.)	CT 204	10
Fine aggregate angularity (% min.)	AASHTO T 304 Method A	45
Flat and elongated particles (% max. @ 3:1)	ASTM D 4791	25
K_c factor (max.)	CT 303	1.7
K_f factor (max.)	CT 303	1.7

Aggregate for RBWC Type G

- 1/2” or 3/8” gradation
- Same as requirements as RHMA-G from Section 39

Aggregate for Type O mixes

The aggregate for BWC – O or RBWC – O shall conform to the 1/2” or 3/8” maximum gradings in Section 39-1.02E, "Aggregate," of the Standard Specifications.

District 10 I-5,
RBWC Open Graded,
Constructed 2005

ME2

ME2 Include the Spec for lime treated aggregate for RAC

MACTEC Employee, 5/7/2007

Emulsion Membrane Application

(Used with both BWC and RBWC)

- High flexibility and bonding in the range of climactic conditions in which bonded wearing courses are placed
- Application rate - 0.20 gal/sy depending on existing conditions.
- Breaks rapidly after spraying to ensure that no water is trapped. The gap-graded nature of the mix allows water to escape, thus promoting breaking of the emulsion.

Emulsion Membrane Spec.

Specification Designation	Test Method	Requirement	
		Min.	Max.
Saybolt-Furol Viscosity, at 25°C, s	AASHTO T59	20	100
Sieve Test on original emulsion (at time of delivery), %	AASHTO T59	-	0.05
24-hour Storage Stability, % (*Note a*)	AASHTO T59	-	1
Residue by Evaporation, %	California Test 331	63	-
Solubility in Organic Solvent, % (*Note b*)	AASHTO T44	97.5	-
Torsional Recovery, measure entire arc of recovery, at 25°C, %	California Test 332	30	-
Penetration (0.01 mm) at 25°C Emulsion used with GGB1 or GGB2 Emulsion used with GGB3 Emulsion used with GGB4	 AASHTO T49 AASHTO T49 AASHTO T49	 70 90 100	 150 180 200

Notes:

a) After standing undisturbed for 24 hours, the surface shall show no white, milky colored substance, but shall be a smooth homogeneous color throughout.

b) The organic solvent shall be from the approved list available from the Transportation Laboratory.

BWC Type G Mix Design

Table 5: BWC Mix Requirements (1)			
Test	**Test Method**	**Requirement**	
		Min	**Max**
Film Thickness, μm	**Gradation surface area factor method; Asphalt Institute MS-2, Table 6.1**	**10.0**	**-**
Tensile Strength Ratio, %	**California Test 371**	**70**	**-**

Note: The optimum binder content is first established so that the film thickness requirement is met. This binder content shall conform to the drain down requirement.

RBWC Type G Mix Design

- Optimum binder content (OBC) determined by California Test 367 with exception.
- The same method used for the RHMA-G mix design.
- TSR requirement may be waived with approval from DME.

Type O Mix Design

- Determined optimum binder content (OBC1) for BWC – O by California Test 368
- The RBWC – O OBC shall then be determined using the following formula:
- OBC2 = (OBC1) x 1.20 where:
- OBC1 = Optimum bitumen content using PG 64-10 paving asphalt
- OBC2 = Optimum bitumen content using asphalt-rubber binder
- Antistrip treatment is required unless waived by DME

Summary

Key components for a successful BWC project:

- Project Selection
- Design
- Materials and Specifications

District 6
Rt. 99

Module 11-2

Construction and Inspection

From… Maintenance Technical Advisory Guide (MTAG)

Topics to be covered

- Understand/Review Specifications
- Safety and Traffic Control
- SWPPP
- Surface Preparation
- Equipment Requirements
  - Calibrations
- Approved Mix design
  - Sampling and Testing
    - Binder
    - Mix
    - Emulsion
- Mix Production and Handling
- Required Application Conditions
- Application of Materials
  - Production Rates
  - Roadway Geometry and Paving Widths
- Application Problems and Solutions

Understand/Review Specifications

- Review Construction Manual Chapter 4
  - Section 92 asphalt binder
  - Section 94 emulsion (emulsion membrane)
  - Section 39 Asphalt Concrete (mix and placement)
- Review RE file notes
- Project special provisions

Safety and Traffic Control

- Traffic control is required both for the safety of the traveling public and the personnel performing the work.
- Traffic control includes placing construction signs, construction cones and/or barricades, flag personnel, and pilot cars required to direct traffic clear of the maintenance operation.

Traffic Control

- Typical release to traffic:
  - 10-20 minutes behind paver for polymer modified binders
  - 20 – 30 minutes for rubberized binders (require sanding)
- Multi-lane highways, consider moving lane closure
- Two-lane roadways ½ to ¾ mile closure
- Thinner lift allows faster production
- Emulsion membrane serves as a tack coat

OPENING TO TRAFFIC

- Traffic can be allowed onto the new surface once rolling is completed and the mix temperature has fallen below 160°F.
- Typically, no post sweeping is required except for RBWC.

Surface Preparation

- Cracks > ¼” should be filled or sealed prior to application
- Do not over-band
- Cover manhole covers, drains, grates, catch basins, and other utility services with roofing paper or equivalent
- Fill any surface irregularities deeper than 1” with dense graded hot mix before applying the BWC.
- Prior to application, sweep the pavement with a rotary broom equipped with metal or nylon broom stock.

CRACK PREPARATION & MATERIAL APPLICATION PROCESS

- Kill weeds - 3 weeks prior
- Remove weeds
- Grind out weeds
- Blow out Cracks
- (If moisture exists), use hot lance to remove moisture
- Material Application
- Apply sealer in cracks

CRACK PREPARATION

185 cfm @ 110 PSI
1/4” nozzle
ratios 1:1 optimum
sterilants
3 weeks prior

3000 F
Velocity
Heat
Lance

Specialty Blades
3/8” wide
removes vegetation

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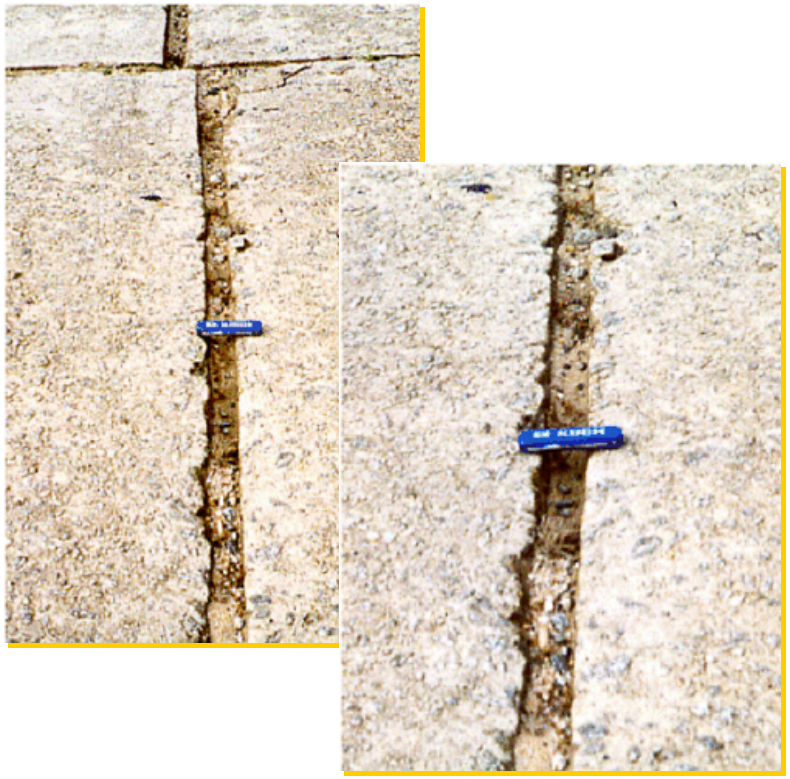
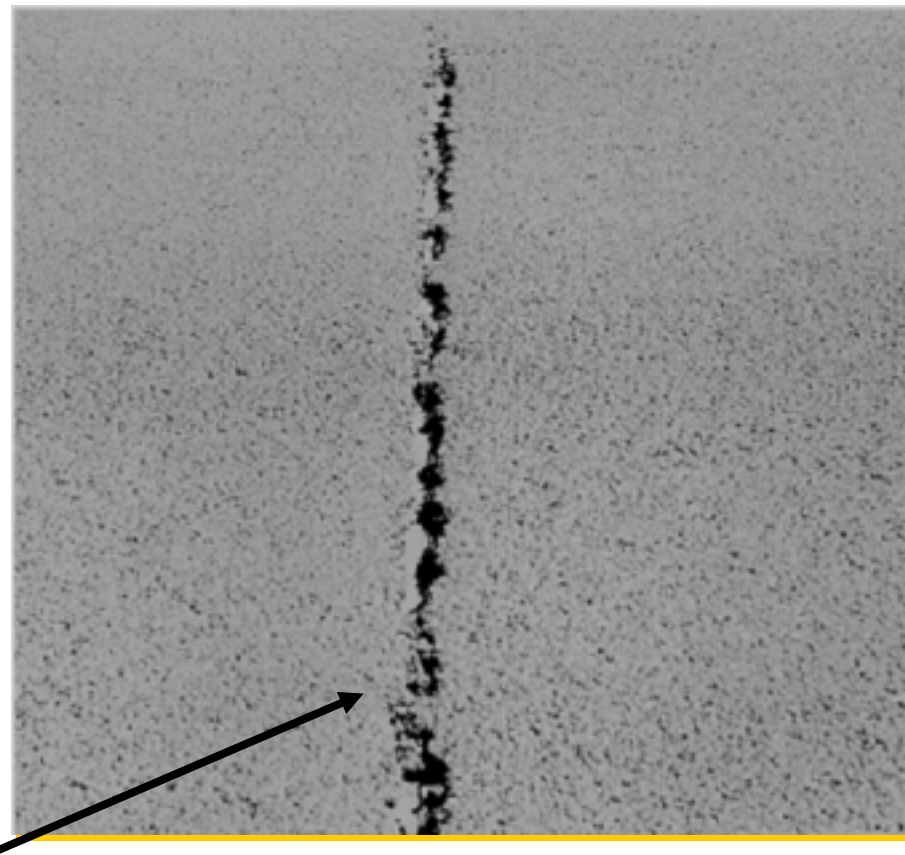
Prep Work Needed





Results of not sealing joint


Minimum one month before paving

Preparation

- Milled Joints
  - Beware of Quarter Crown Issues
  - Transverse cuts should be 2 times paving depth

Roadway Cleanliness

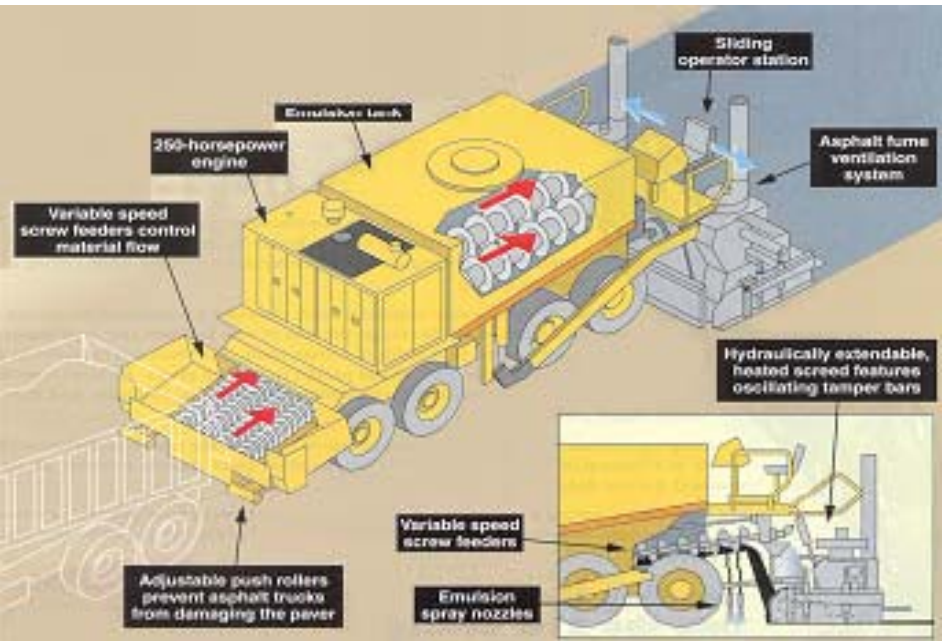
Construction Entrance Not Swept Prior to BWC Application

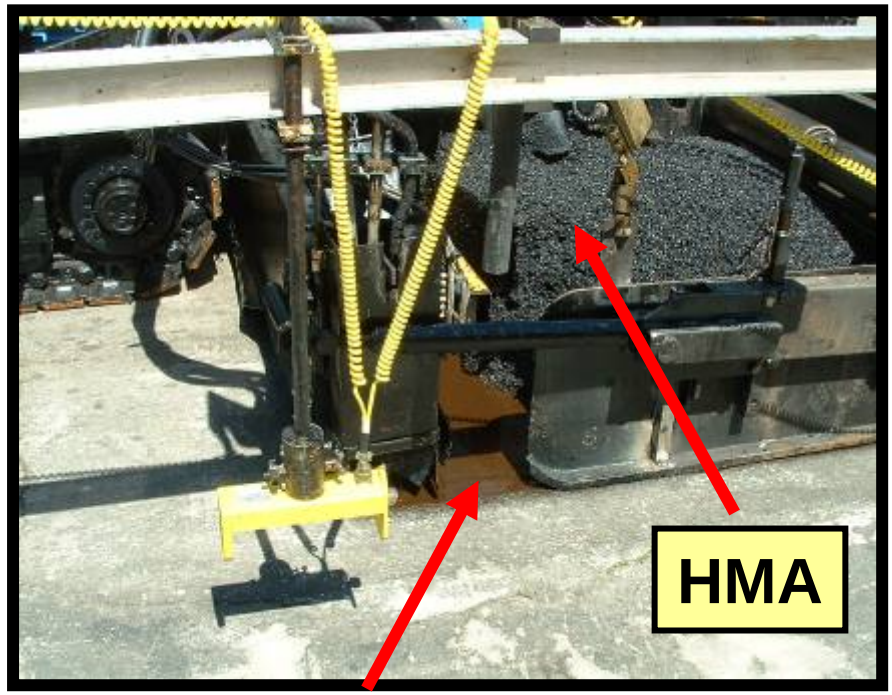
Miscellaneous Items

- Edge grinding
- Crack seal hot applied min one month prior
- Patching - hot mix only, cold mix continues to rut
- Utilities – Adjustments
- Loops - Move
- Dig Outs – Prior to paving
- Signing and Striping

Equipment Requirements

- The binder application and hot mix spreading function are combined into a single unit.





Spray Paver Calibration Procedure

1. Once proper nozzles sizes have been selected, make sure all nozzles are clean and working.
2. Measure pad width and length to the nearest 0.1 of an inch and record.
3. Weigh calibration pads to the nearest 0.1 g and record.
4. Place plastic container on balance. Either record the weight of the plastic container or zero out the weight of the plastic container.
5. Place calibration pads a minimum of 5 feet in front of the emulsion spray bar in the direction of travel. Use two calibration pads to get an average representative distribution. Place the second pad a minimum of 1 foot behind the first pad.

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Spray Paver Calibration Procedure

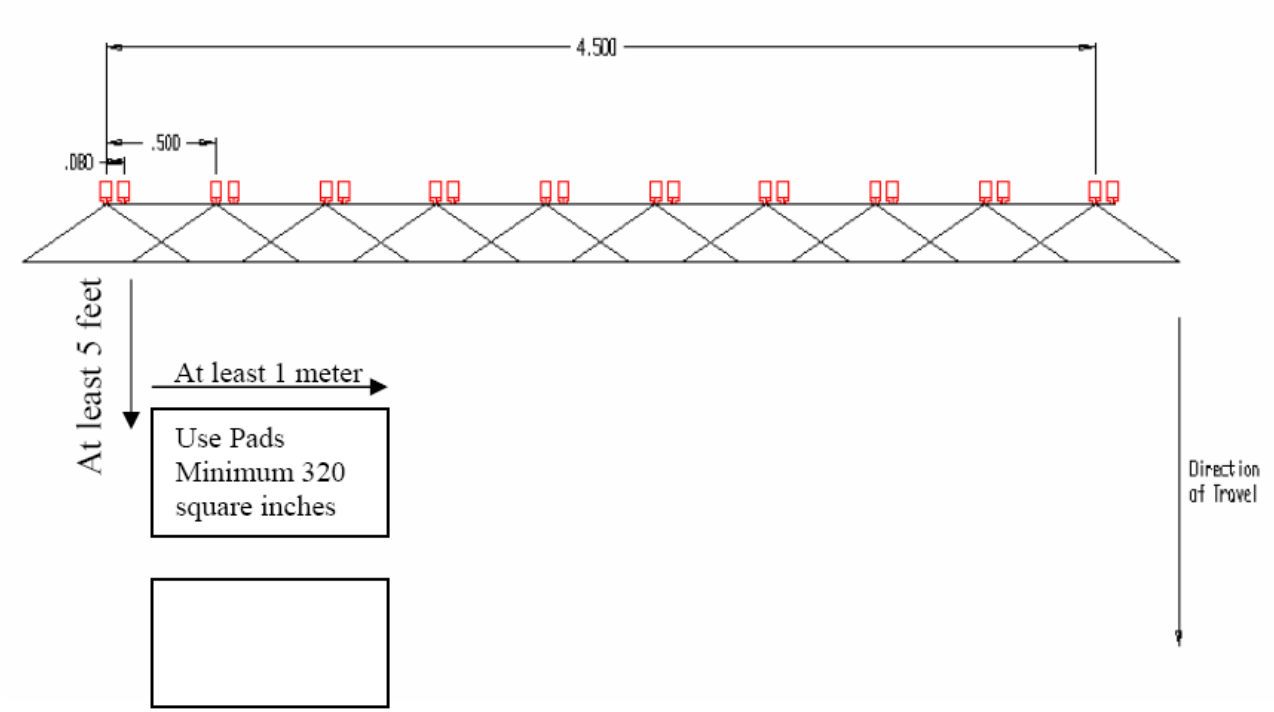
6. Make sure the emulsion pump and bar pressure is set to optimal manufactures operating range.
7. Engage the paver in automatic mode and allow the paver to come up to full paving speed before passing over the calibration pads.
8. Once the spray bars has passed over the calibration pads, carefully fold the edges of the calibration pads towards the center and roll the pad up so no emulsion will be lost when picked up.

Spray Paver Calibration Procedure (Cont.)

9. Bring the plastic container to the calibration pad and place the pad in the container.
10. Record weight of the calibration pads.
11. It will be necessary to clean the plastic container before the second calibration pad is weighed or the weight of the plastic container will have to be re-zeroed as emulsion from the first pad will increase the weight of the container.

Spray Bar Calculation Procedure

Pad Placement:



Spray Bar Shot Rate Calculation

$$ShotRate(gal/yd^2) = \frac{PW(g)}{PA(in^2)} \times 0.337$$

- **PA (in^2) = Pad Area = L (in) * W (in)**
- **PW (g) = Weight of Emulsion = Pad and Emulsion (g) – Pad (g)**

- **Example:**

Pad Length	= 9.5 in
Pad Width	= 17.25 in
Weight of Pad and Emulsion	= 371.2 g
Weight Pad	= 300 g

PW = 371.2 – 300.0 = 71.2 g
PA= 9.5 * 17.25 = 163.9 in^2

$$ShotRate\ gal/yd^2 = \frac{71.2\,g}{163.9\,in^2} * 0.337$$

Shot Rate = 0.15 gal/yd^2

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Approved Mix Design

PROJECT -	Caltrans Rte 29	W.O.	US.CA.NC.2004.0284
CONTRACTOR -	Windsor Fuel Company	DATE COMPLETED:	9-Jun-04
BINDER -	Valero GGB1	TECHNOLOGIST:	Michael Exline
SUPPLIER -	Syar	TECHNICAL CONTACT:	Stephane Charmot
TECHNICAL MARKETING REP -	Scott Metcalf (909) 228-2159	PHONE:	(801) 673 6579

Asphalt Content Percentage (BWA)	6.4	%	(By Weight of Aggregate)
Recommended Starting emulsion shot rate =	0.20	gal/yd^2	(Range: 0.12 to 0.26 gal/yd
Recommended Starting emulsion shot rate =	0.91	l/m^2	(Range: 0.6 to 1.2 l/m^2)

AGGREGATE GRADATIONS - INDIVIDUAL AND BLEND

		Sample ID	Coarse	Fine		
		KMC Lab No.	2004.0194	2004.0195	Blend	12.5-mm Max Agg
		% in Blend	70.0	30.0	100.0	
	SIEVE					Limits
1"	25.00 mm		100	100	100	100 - 100
3/4"	19.00 mm		100	100	100	100 - 100
1/2"	12.50 mm		92	100	94	85 - 100
3/8 "	9.50 mm		49	100	64	60 - 80
#4	4.75 mm		4	100	33	28 - 38
#8	2.36 mm		1	97	30	25 - 32
#16	1.18 mm		1	63	20	15 - 23
#30	0.600 mm		1	38	12	10 - 18
#50	0.300 mm		1	23	8	8 - 13
#100	0.150 mm		1	14	6	5 - 11
#200	0.075 mm		0.8	9.6	3.4	3 - 8
	Aggregate Gsb		2.742	2.651	2.714	
	FAA (T304)				47.0	46 min
	Sand Equivalency (T176)			64.6		47 min
	Meth. Blue (TP57)			4.0		Report Only
	F & E, (3:1) (D4791)		14.0			25% max
	Micro-Deval (TP58)		10.0			Report Only
	LA. Abrasion (T96)		15.9			35% max
	Crushed Coarse Aggregate, % (CT 205)		100			90% min
	Crushed Fine Aggregate,% (CT-205)		100			85% min
	Water Absorption (T84& 85)		1.8	2.8		

Gradation Surface Area Factor =	3.85	m^2/kg	
Estimated Film Thickness =	12.9	µm	10.0 µm min
Maximum theoritical Specific Gravity =	2.637	g/cm3	
Unconditioned Tensile Strength =	112.2	psi	Report Only
Conditioned Tensile Strength (1FT) =	97.1	psi	Report Only
Tensile Strength Ratio =	86.6	%	Report Only
Draindown Test (CT 368) =	0.5 (*)	g	4 max
Film Stripping (CT 302) =	0 (*)	%	25 max

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Sampling and Testing Required

California Test 125 **July 2002**

- **METHODS FOR SAMPLING HIGHWAY MATERIALS AND PRODUCTS USED IN THE ROADWAY STRUCTURAL SECTIONS**
- **ASPHALT CONCRETE**
  - Aggregates . . . Part 1, Sections 1-2
  - Asphalt . . . . . Part 6, Sections 1-3
  - Modified Asphalt Concrete . . . . Part 7, Section 4
- **BITUMINOUS SEAL**
  - Polymer Modified Asphalt Emulsion . Part 6, Section 4

Mix Production and Handling

- Mixing temperatures < 350°F
- Storage time < 12 hours.
  - A drain down test should be performed to ensure binder does not drain out of the mixture.
- All mixing plants must be calibrated to California Test Method CT 109.
- BWC mixes may be treated with an anti-stripping agent or lime if required.

Required Application Conditions

- May be applied on damp, but not wet, surfaces.
- Minimum air and pavement temperature requirements:
  - 45°F and rising for PG 76-22PM
  - 50°F for PG 64-28PM
  - 55°F for all open graded mixes and rubberized binders
  - 60° F recommended surface temperature
- No freezing conditions are allowed in the first 24 hours, the emulsion-based tack coat requires about one day to fully cure.

Application of BWC - Emulsion

- Polymer modified emulsion membrane
  - 120° - 180°F placement temp
  - Average application rate of 0.20 gal/sy with adjustments depending on the surface being covered

Asphaltic Emulsion Membrane Minimum Residual Rates	
Surface to Receive Asphaltic Emulsion Membrane	**Minimum Residual Rates (gallons per square yard)**
PCC pavement	0.09
Dense, compacted, new HMA surface	0.11
Open textured, dry, aged or oxidized HMA surface	0.13

Application of BWC - HMA

- Follow good paving practice
- No windrowing and pick up machines
- MTV recommended

- Paving Depth:
  - No. 4 (does contain some 3/8”) – **minimum** application thickness of 5/8”
  - 3/8” - **minimum** application thickness of 3/4”
  - 1/2” - **minimum** application thickness of 1”

Application of BWC – HMA

- Delivery temperature 285°F - 350°F.
- Longitudinal joints
  - Straight or correctly aligned to the curvature of the roadway
  - Never in the wheel paths

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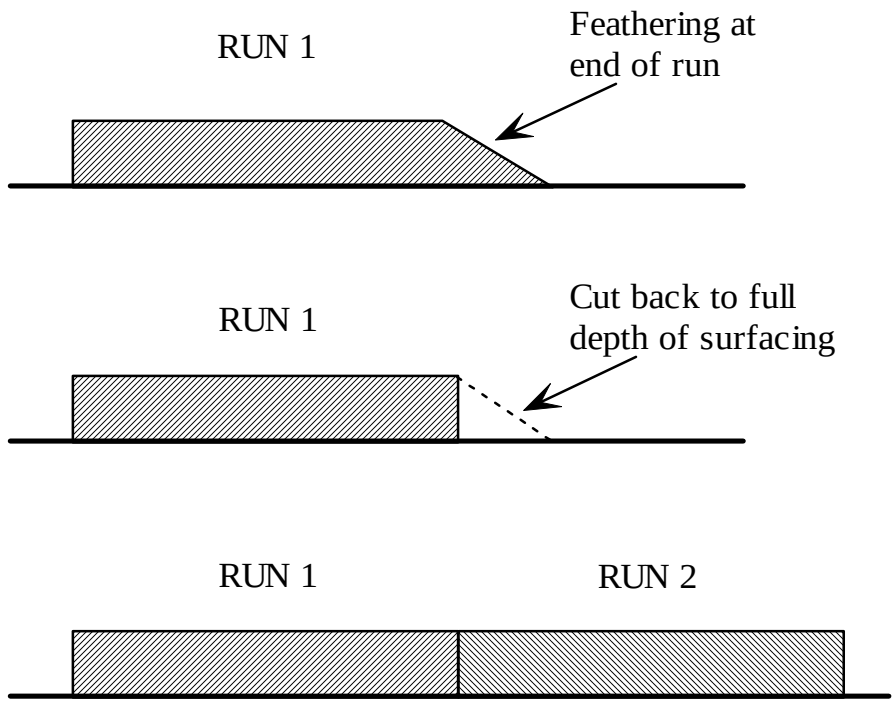
Application of BWC – HMA

- Cut out the existing flexible pavement to a depth of 1.2 in and tapered back a distance of 10 ft to provide a key for the new surfacing.
- Square off end of each run were feathering begins.



Construction

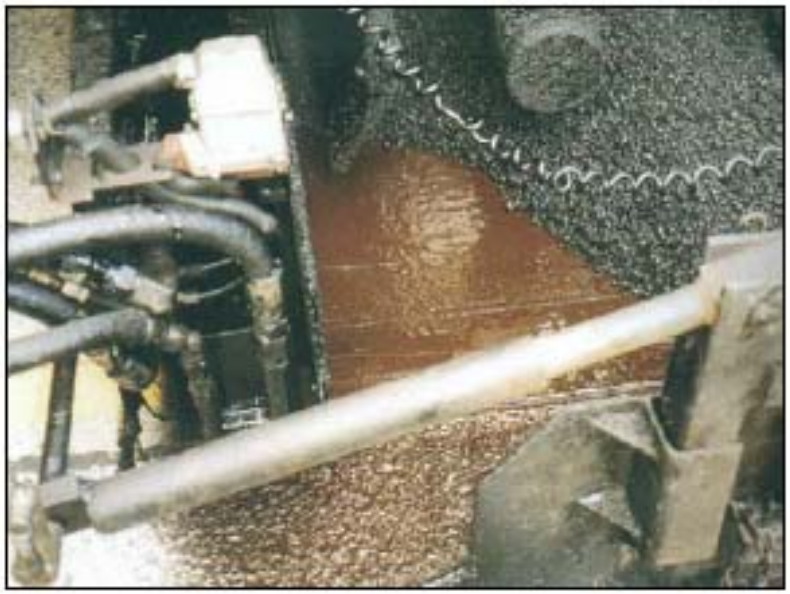


Figure 4: Emulsion Membrane and Mix Spreading (11)

Figure 5: Freshly Laid BWC (11)

Construction

Trimming necessary. No overlap during construction due to emulsion membrane.

Rolling operation showing traffic control.

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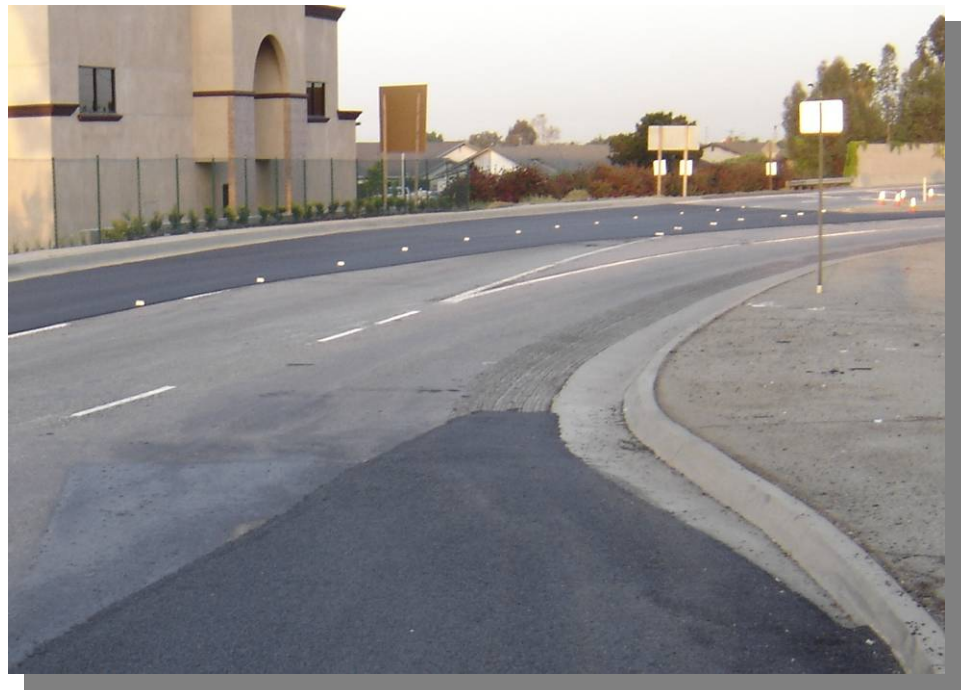
Paving Miscellaneous Areas

- Miscellaneous areas should be paved prior to paving the main line
- Hand work



Application

Roller position relative to paver

- A minimum of 2 coverages with 2 steel drum tandem roller is required for compacting a BWC.
- Rollers must be operated in static mode only.
- Rolling must be carried out before the temperature, at mid layer of the mix, falls below 200°F.

Production Rates & Paving Days

- Production Rate
  - Mainline Paving - 125 tons per hour
  - Returns/Turn pockets - 40-50 tons per hour

Application Problems & Solutions

PROBLEM	SOLUTIONS
Surface Waves	▪ Ensure the head of material in front of the paver screed is at the correct height and does not fluctuate (i.e., rise and fall). ▪ Ensure the screed is not worn or set incorrectly. ▪ Ensure the mix is not too stiff or has not fallen below 285°F. ▪ Ensure the dump trucks do not bump the paving unit as this can cause long frequency waves resulting in increased pavement roughness. ▪ Ensure grade control equipment (if in use) is functioning properly
Wash Boarding	▪ Slow roller down.
Tearing	▪ Ensure the paving unit is being operated correctly. ▪ Ensure the mix is not too cold (i.e., below 285°F) or too stiff. ▪ May be fixed by adjusting the degree of crown and ensuring mix temperature is correct. ▪ Ensure application is not too thin
Nonuniform Texture-Segregation	▪ Ensure the mixture is not separating in the hopper or during transportation. ▪ Ensure the paving unit is set up properly. ▪ Ensure the mix temperature is at least 285°F. ▪ Check the mix design for poor grading. Adjust if necessary.

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Application Problems & Solutions

Screed Marks	▪Ensure the paving unit is set up correctly and that the screed in not worn or dirty. ▪Ensure the mix temperature is at least 285°F. ▪Compare grading with the mix design data. Adjust if necessary. ▪Ensure mix is in specification.
Roller Checking & Marks	▪Ensure the roller does not cause a wave in the mat in front of the roller (i.e., mix too hot). Wait until the mix cools further. ▪Check the mix design for too much asphalt in the mix, or too much middle size sand in the gradation. Adjust mix if necessary.
Bleeding & Fat Spots	▪Ensure the mix temperature is not too hot (greater than 350°F). ▪Compare with the mix design for binder content or aggregate grading. Adjust mix if necessary. ▪Ensure there is no moisture in the mix or on the pavement. ▪Ensure the tack coat application rate is not too high for the surface to which it is applied. Tight, smooth surface require less tack coat than do more open surfaces. Reduce application rate on existing surfaces that exhibit bleeding. ▪Ensure spray bar equipment is operating properly. ▪Ensure aggregates are dry before mixing with asphalt in the hot mix plant, that pavement is not bleeding, that pavement is dry, and that mix is correctly designed for traffic and aggregate.

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Application Problems & Solutions

PROBLEM	SOLUTIONS
Delamination	▪Ensure adequate tack coat is applied. ▪Ensure the mix is above minimum application temperature (285°F). ▪Ensure the mix is not below the minimum compaction temperature (200°F). ▪Ensure the existing pavement surface temperature is above the minimum (i.e., 50°F) before paving. ▪Ensure the surface is cleaned immediately before paving. ▪Ensure roller drums are not dirty and have working spray systems.
Poor Transverse Joints	▪Ensure butt joints are properly constructed.
Poor Longitudinal Joints	▪Ensure proper joint construction practices are followed, especially when compacting thin lifts.
Excessive Ravel	▪Ensure the mix design meets project specifications, particularly that the mix contains sufficient binder. ▪Ensure compaction is carried out above the minimum temperature (i.e., 194°F).

Summary

Key components for the successful construction of a BWC project:

- Safety and Traffic Control
- Surface Preparation
- Equipment Requirements
- Approved mix design
- Mix production and handling
- Required Application Conditions
- Application of Material
- Application troubleshooting

District 6, Rt. 99

Thank You

Questions?