Concrete Overlays – Case Studies in Maryland

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

DFI
Development Facilitators, Inc.

OMT – Pavement and Geotechnical Division
and
Development Facilitators, Inc.

March 12, 2019

Overview

- Introduction
- Selection of Project Candidates
- Design Considerations
- Bonded vs Unbonded Concrete Overlay
- Concrete Overlay Design method's used in Maryland
- Resources and References

Introduction

- Evan Howard
- Graduate of Morgan State University with B.S. in Civil Engineering (2009) and M.S in Civil Engineering (2015).
- Worked for PENNDOT for 1 year as a Pavement Designer.
- Currently working as Pavement Design Team Leader for District 3 for the past 2 years. I have been working for MD State Highway Administration for 8 years.
- Phone No.: 443-572-5174
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Selection of Project Candidates

- Input from the District and Maintenance Shop
- Partnership – MDSHA and ACPA
- MDSHA's Pavement Design Guide Treatment Matrices

Selection of Project Candidates (Cont)

- Is the existing pavement a good candidate for concrete overlay ?

Selection of Project Candidates (Cont)

- Perform a Desk review which includes
  - Construction history/repair history.
  - As-built plans of previous projects.
  - Videolog viewer of previous years.
  - PM Base data and performance condition of the roadway for IRI, Cracking, Rutting and Friction).
  - Material and Soil Properties from previous projects.

Selection of Project Candidates (Cont)

- Perform a Site Visit of the project.
  - Assess the distress types and severity of the pavement.
  - Typical asphalt pavement failures at intersections are as followed: 1. Slippage, 2.Rutting/Shoving 3. Cracking.
  - Location of Distresses, e.g. are they out in the intersection, beyond the stop bar ? Mainline ? Turn lanes ?
  - Is the section an open or closed section ? Is there curb and gutter in the area.
  - Grade and Elevation Restrictions.
  - Assess the existing drainage conditions.
  - Check Existing ground utilities.

Selection of Project Candidates (Cont)

- Pictures of Slippage

Selection of Project Candidates (Cont)

- Pictures of Rutting

Selection of Project Candidates (Cont)

- Pictures of Rutting

Selection of Project Candidates (Cont)

- Pictures of Cracking

Selection of Project Candidates (Cont)

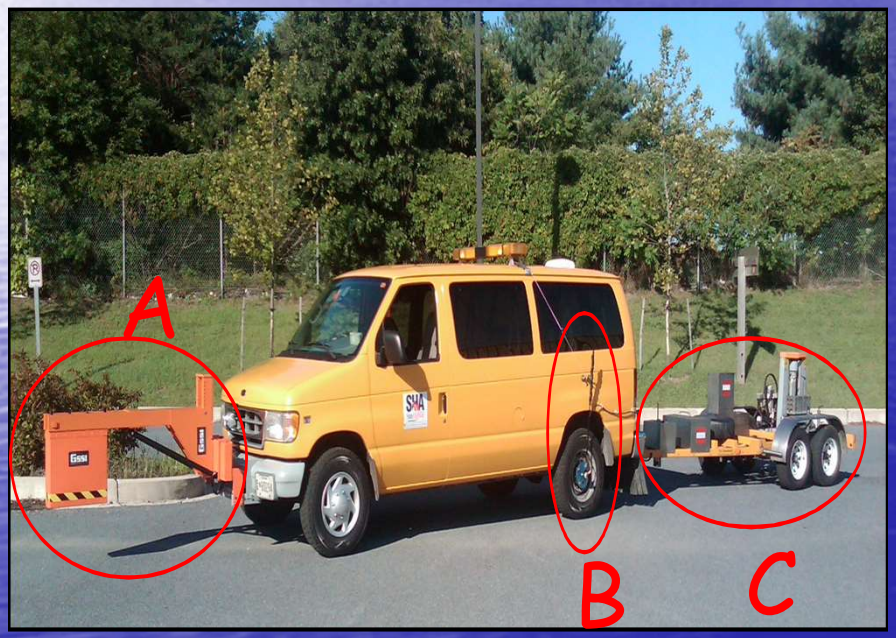
- Pictures of Cracking

Selection of Project Candidates (Cont)

- Perform Field Exploration (Cores, FWD Testing and Ground Penetration Radar).
  - Used to determine pavement thicknesses (concrete overlay vs. reconstruction).
  - Used to determine material properties such as pavement section modulus ,subbase stone modulus and subgrade soil strength modulus.

Selection of Project Candidates (Cont)

Ground Penetration Radar/Falling Weight Deflectometer



Core Rig

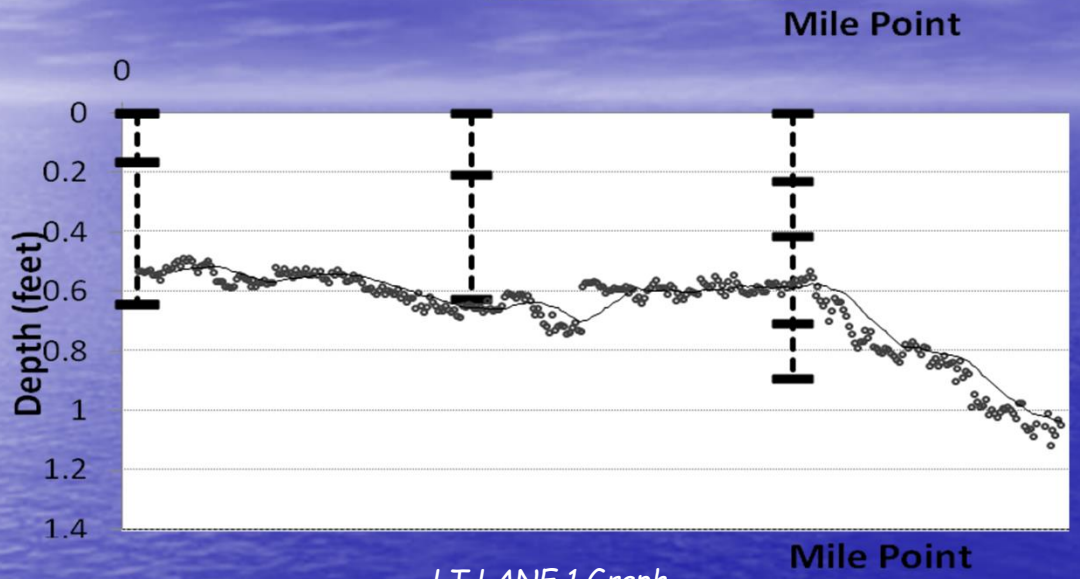
A. 2.0 GHz horn antenna
B. Wheel-mounted Distance Measuring Instrument (2 Readings Taken every foot)
C. Existing FWD equipment

Selection of Project Candidates (Cont)

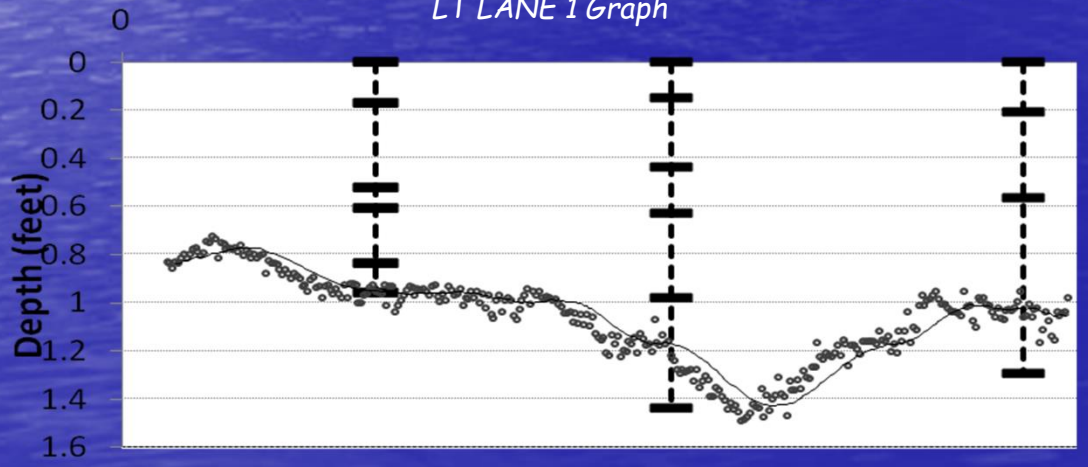
Pavement Core Log

County:	**Anne Arundel**				**Coring Date:** 04/02/2012
Location:	**MD 2 At MD 214**				**Mile Points:**
Core	**Direction**	**Lane**	**Mile Point**		**Description**
1	S	1	340 ft before	0" - 7.75"	BITUMINOUS CONCRETE
C1		Left turn	MD 214	7.75" -	STONE BASE
		4' from yellow			
2	S	1	215 ft	0" - 7.5"	BITUMINOUS CONCRETE
C6		Left turn	before	7.5" -	STONE BASE
		4' from yellow	MD 214		
3	S	2	145 ft	0" - 17.25"	BITUMINOUS CONCRETE
C8		Left turn	before	17.25" -	SAND
		5' from white	MD 214		
		skip			
4	S	2	20 ft	0" - 15.5"	BITUMINOUS CONCRETE
C12		Left turn	before	15.5" -	SAND
		6' from white	MD 214		
		skip			
5	S	1	340 ft	0" - 8.5"	BITUMINOUS CONCRETE
C2		5' from left	before	8.5" -	STONE & GRAVEL
		white skip	MD 214		
6	S	1	215 ft	0" - 9.25"	BITUMINOUS CONCRETE
C5		5' from left	before	9.25" -	STONE & GRAVEL
		white skip	MD 214		
7	S	1	85 ft	0" - 13.5"	BITUMINOUS CONCRETE
C10		6' from left	before	13.5" -	STONE BASE
		white skip	**MD 214**		
8	S	2	340 ft	0" - 9.25"	BITUMINOUS CONCRETE
C3		5' from left	before	9.25" -	STONE & GRAVEL
		white	MD 214		
9A	S	2	220 ft	0" - 8"	BITUMINOUS CONCRETE
		5' from left	before	8" -	SAND
		white skip	MD 214		
9B	S	2	170 ft	0" - 8.25"	BITUMINOUS CONCRETE
C7		5' from left	before	8.25" -	SAND
		white skip	MD 214		
10	S	Right turn	215 ft	0" - 7.25"	BITUMINOUS CONCRETE
C4		5' from curb	before	7.25" -	STONE BASE

Selection of Project Candidates (Cont)

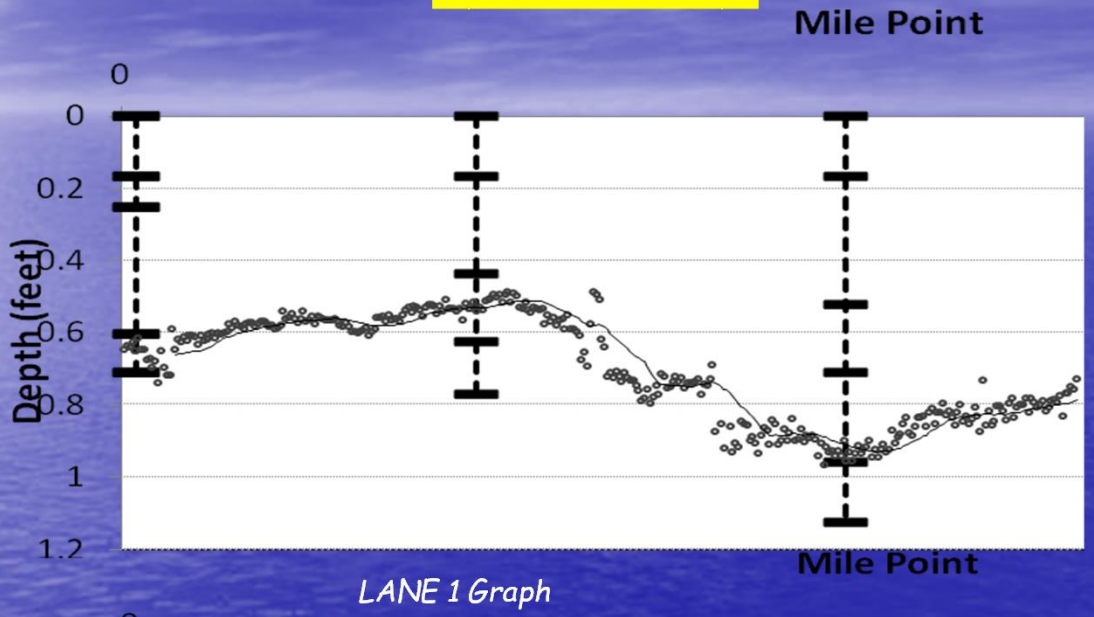


LT LANE 1 Graph

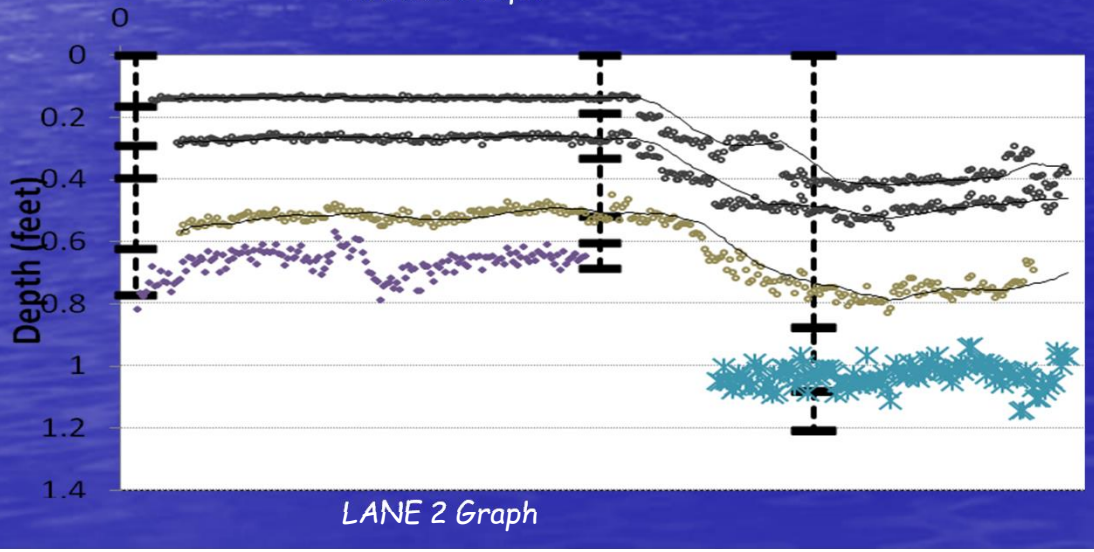


LT LANE 2 Graph

Selection of Project Candidates (Cont)

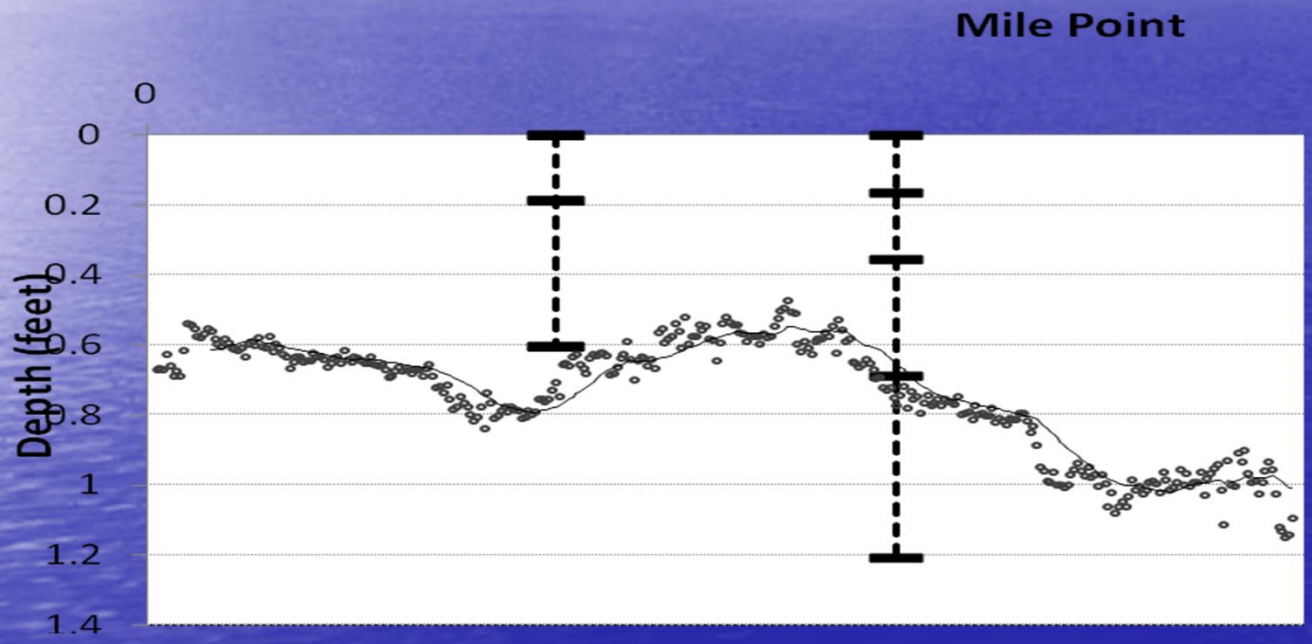


LANE 1 Graph



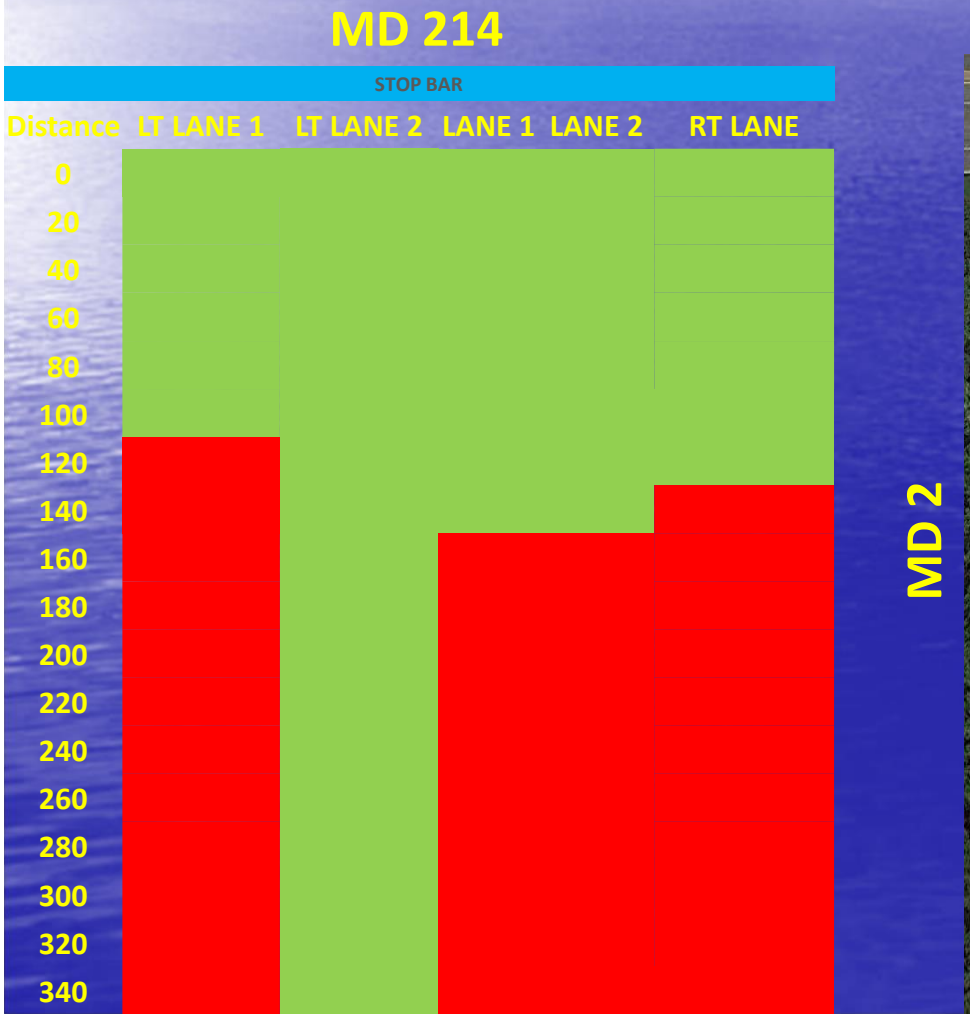
LANE 2 Graph

Selection of Project Candidates (Cont)



RT LANE Graph

Selection of Project Candidates (Cont)



Selection of Project Candidates (Cont)

- Request Traffic Volume and Truck Percentage from Travel Forecasting Division.

- Discuss Maintenance of Traffic (MOT) and Detour options with District Traffic and Construction Personnel.

Design Considerations

- Based on cores/GPR, is a concrete overlay feasible or reconstruction ?
- Concrete intersection construction limits based on limits of pavement distresses, stopping distance and average Queue Length.
- Turning Radius Minimums.
- Thickness Design (base and subgrade requirements).
- Jointing detail

Design Considerations (Cont)

- Pavement profiles.
- Concrete materials (high early strength for fast-track paving?).
- Concrete to asphalt transitions.
- Traffic detection systems.
- Coordination with local agencies/first responders

Bonded vs Unbonded Concrete Overlay

- Bonded or Unbonded Concrete Overlay ?

Bonded vs Unbonded Concrete Overlay

- Bonded Concrete Overlay
  - 15 to 25+ year Design Life
  - are used to add structural capacity and/or eliminate surface distresses when the existing pavement is in good structural condition.
  - Rely on bond with existing asphalt pavement to function.
  - Thickness ranges between 2 inches to 5 inches.
  - Joint spacing are typically between 3 inches to 6 inches.
  - Used as Resurfacing/Minor Rehabilitation.

Bonded vs Unbonded Concrete Overlay

- Unbonded Concrete Overlay
  - 15 to 30+ Design Life
  - are used to rehabilitate pavements with some structural deterioration
  - does not rely on bond with existing asphalt pavement to function.
  - Thickness ranges between 4 inches to 11 inches on concrete and composite pavements; typically 6 inches. minimum on asphalt pavement less than 6 inch thick after milling.
  - Used as Minor/Major Rehabilitation.
  - Overlay performs as a new pavement and the existing provides a stable base.

Bonded vs Unbonded Concrete Overlay

Summary of Concrete Overlays

National Concrete Pavement Technology Center

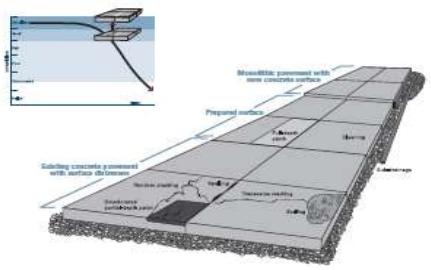
ctre Iowa State University

Bonded Family

Thickness: 2–5 in. depending on desired life (15–25+ years), anticipated traffic loading, and condition of underlying pavement

Bonded Concrete Overlays of Concrete Pavements

— Overlay and existing concrete pavement act as one monolithic pavement



Existing pavement condition

Good structural condition; some surface distress OK

Applications

- Where increase in traffic loads requires more structural capacity (related benefit: improves friction, noise, and rideability)
- To eliminate surface defects such as extensive scaling or surface cracking
- Where vertical clearances must be met
- In mill and inlay sections

Keys to success

- Existing pavement surface must be prepared to enhance bonding to the overlay
- Overlay's aggregate thermal properties (coefficient of thermal expansion) must be similar to (or lower than) existing pavement's to minimize shear stress in bond
- Working cracks in the existing pavement should be repaired (or the overlay should be sawed over the crack) to prevent the crack from reflecting through the overlay
- Existing joints must be in fair condition or repaired
- Thinner overlays may shorten sawing window
- Transverse joints in the overlay must be sawed full depth plus ½ in. (1.3 cm); longitudinal joints must be at least T/2
- Joints in the overlay must align with those of existing pavement because the structure must move monolithically
- Width of transverse joints in the overlay must be equal to or greater than the underlying crack width at the bottom of the existing transverse joint
- Application of curing compound or other curing methods must be timely and thorough, especially at edges

Bonded Concrete Overlays of Asphalt Pavements

— Overlay and existing concrete pavement act as one monolithic pavement

Existing pavement condition

Fair or better structural condition with surface distress

Applications

- Where increase in traffic loads requires more structural capacity
- To eliminate surface defects such as rutting and shoving
- To improve friction, noise, and rideability
- Where vertical clearances must be met

Keys to success

- Milling of existing asphalt may be required to eliminate surface distortions of 2 in. (5.1 cm) or more and to help provide good bond; minimal spot repairs may be required
- Asphalt surface temperature must be maintained below 120°F (48.9°C) when placing overlay
- Joints in overlay should be sawed in small, square panels
- Transverse joints must be sawed T/3 (with special attention to thickened overlay over asphalt ruts)
- Joints in the overlay should not be placed in wheel paths, if possible
- Thinner overlays may shorten sawing window; additional saws are likely to be required
- Application of curing compound or other curing methods must be timely and thorough, especially at edges

Bonded Concrete Overlays of Composite Pavements

— Overlay and existing concrete pavement act as one monolithic pavement

Existing pavement condition

Fair or better structural condition with severe surface distress

Applications

- Where increase in traffic loads requires more structural capacity
- To eliminate surface defects such as rutting and shoving
- To improve friction, noise, and rideability
- Where vertical clearances must be met

Keys to success

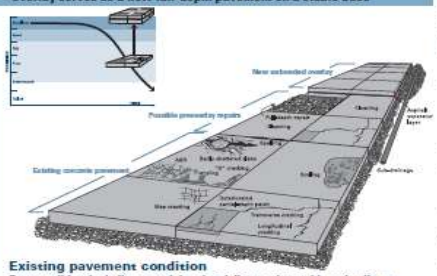
- If the existing pavement profile indicates isolated areas of vertical distortion in the underlying concrete that could signal movement from drainage or materials-related distresses, repairs may be necessary
- Milling of existing asphalt may be required to eliminate surface distortions of 2 in. (5.1 cm) or more and to help provide good bond; minimal spot repairs may be required
- Existing asphalt pavement surface temperature must be maintained below 120°F (48.9°C) when placing overlay
- Joints in overlay should be sawed in small, square panels
- Transverse joints must be sawed T/3 (with special attention to thickened overlay over asphalt ruts)
- Joints in the overlay should not be placed in wheel paths, if possible
- Thinner overlays may shorten sawing window; additional saws are likely to be required
- Application of curing compound or other curing methods must be timely and thorough, especially at edges

Unbonded Family

Thickness: 4–11 in. depending on desired life (15–30+ years), anticipated traffic loading, and condition of underlying pavement

Unbonded Concrete Overlays of Concrete Pavements

— Overlay serves as a new full-depth pavement on a stable base



Existing pavement condition

Poor condition, including materials-related distress, but stable and uniform

Applications

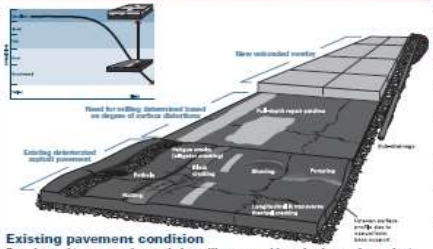
- To restore or enhance pavement's structural capacity
- To increase pavement life equivalent to full-depth pavement
- To improve surface friction, noise, and rideability

Keys to success

- Full-depth repairs should be considered only at isolated spots where structural integrity needs restoring
- A separation layer (typically 1 in. asphalt) is required to separate overlay from the existing concrete and eliminate reflective cracking (to reduce pore pressure and minimize stripping of this separation layer under high truck traffic, provide adequate drainage and a more porous asphalt)
- Some states are experimenting with geotextile materials for the separation layer
- Faulting of 3/8 in. (9.5 mm) or less in the existing concrete pavement is generally not a concern when asphalt separation layer is 1 in. (2.5 cm) or more
- Joints should be sawed in overlay as soon as possible because the sawing window may be short
- Shorter joint spacing than normal in the overlay can help reduce curling and warping stress
- It is not critical to mis-match overlay joints to the underlying joints

Unbonded Concrete Overlays of Asphalt Pavements

— Overlay serves as a new full-depth pavement on a stable base



Existing pavement condition

Deteriorated (severe rutting, potholes, alligator cracking, shoving, and pumping) but stable and uniform

Applications

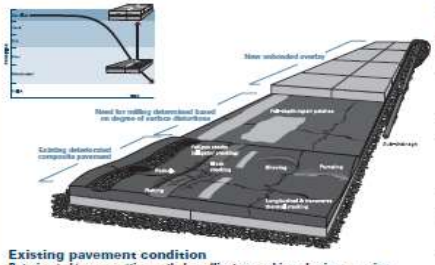
- To restore or enhance pavement's structural capacity
- To increase pavement life equivalent to full-depth pavement
- To eliminate rutting and shoving problems
- To improve surface friction, noise, and rideability

Keys to success

- Milling of existing asphalt may be required to eliminate surface distortions of 2 in. (5.1 cm) or more
- Full-depth repairs should be considered only at isolated spots where structural integrity needs restoring
- Concrete patches in the existing pavement should be separated from the overlay with a thin layer of emulsion, fabric, or other bond breaker; or joints should be sawed in the overlay around the concrete patch perimeter
- Joints should be sawed in overlay as soon as possible because the sawing window may be short
- Surface temperature of existing asphalt pavement should be maintained below 120°F (48.9°C) when placing overlay
- Partial bonding between the overlay and the existing asphalt pavement is acceptable and may even improve load-carrying capacity

Unbonded Concrete Overlays of Composite Pavements

— Overlay serves as a new full-depth pavement on a stable base



Existing pavement condition

Deteriorated (severe rutting, potholes, alligator cracking, shoving, pumping, and past materials-related distress) but stable and uniform

Applications

- To restore or enhance pavement's structural capacity
- To increase pavement life equivalent to full-depth pavement
- To eliminate rutting and shoving problems
- To improve surface friction, noise, and rideability

Keys to success

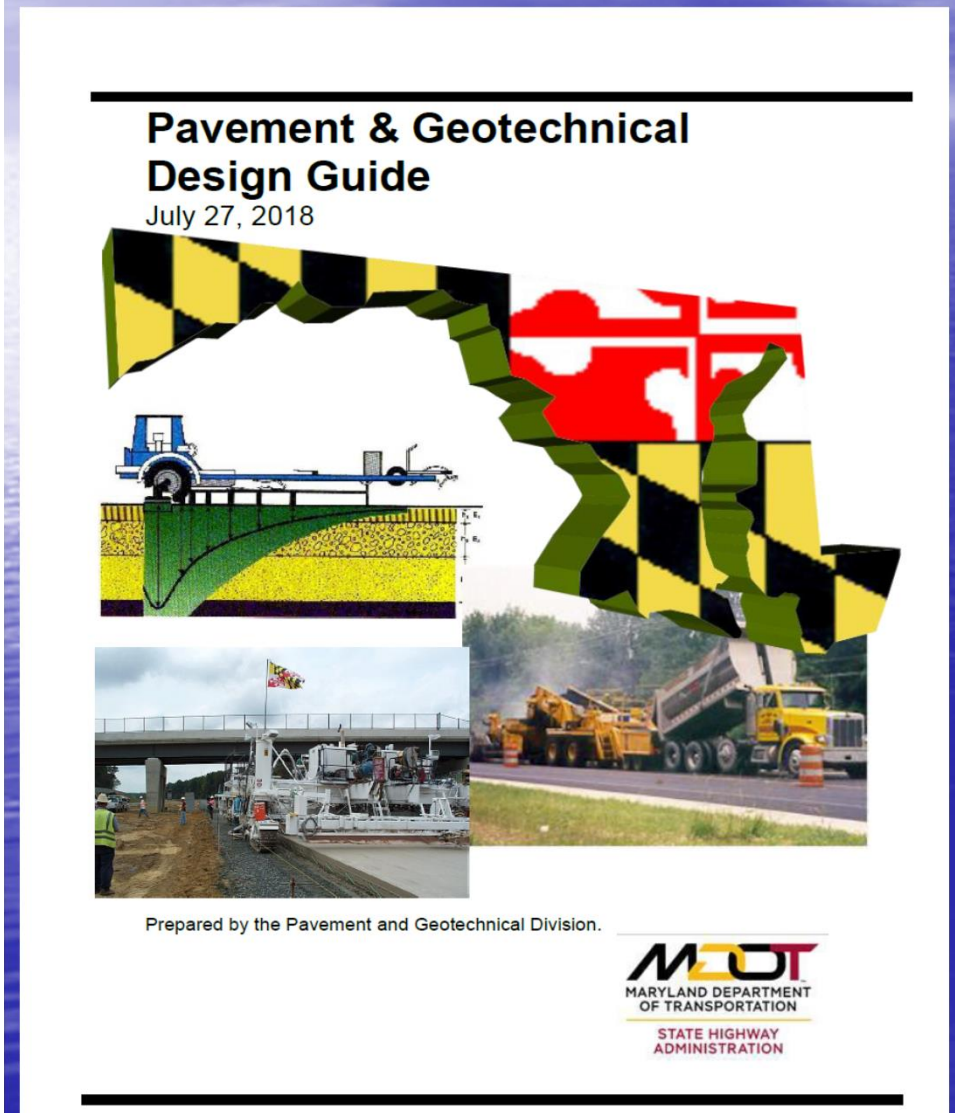
- Milling of existing asphalt may be required to eliminate surface distortions of 2 in. (5.1 cm) or more
- If the existing pavement profile indicates isolated areas of vertical distortion in the underlying concrete that could signal movement from drainage or materials-related distresses, repairs may be necessary
- Full-depth repairs should be considered only at isolated spots where structural integrity needs restoring
- Concrete patches in the existing asphalt pavement surface should be separated from the overlay with a thin layer of emulsion, fabric, or other bond breaker; or joints should be sawed in the overlay around the concrete patch perimeter
- Joints should be sawed in overlay as soon as possible because the sawing window may be short
- Surface temperature of the asphalt layer of the existing composite pavement should be maintained below 120°F (48.9°C) when placing overlay
- Partial bonding between the overlay and the asphalt layer of the existing composite pavement is acceptable and may even improve load-carrying capacity

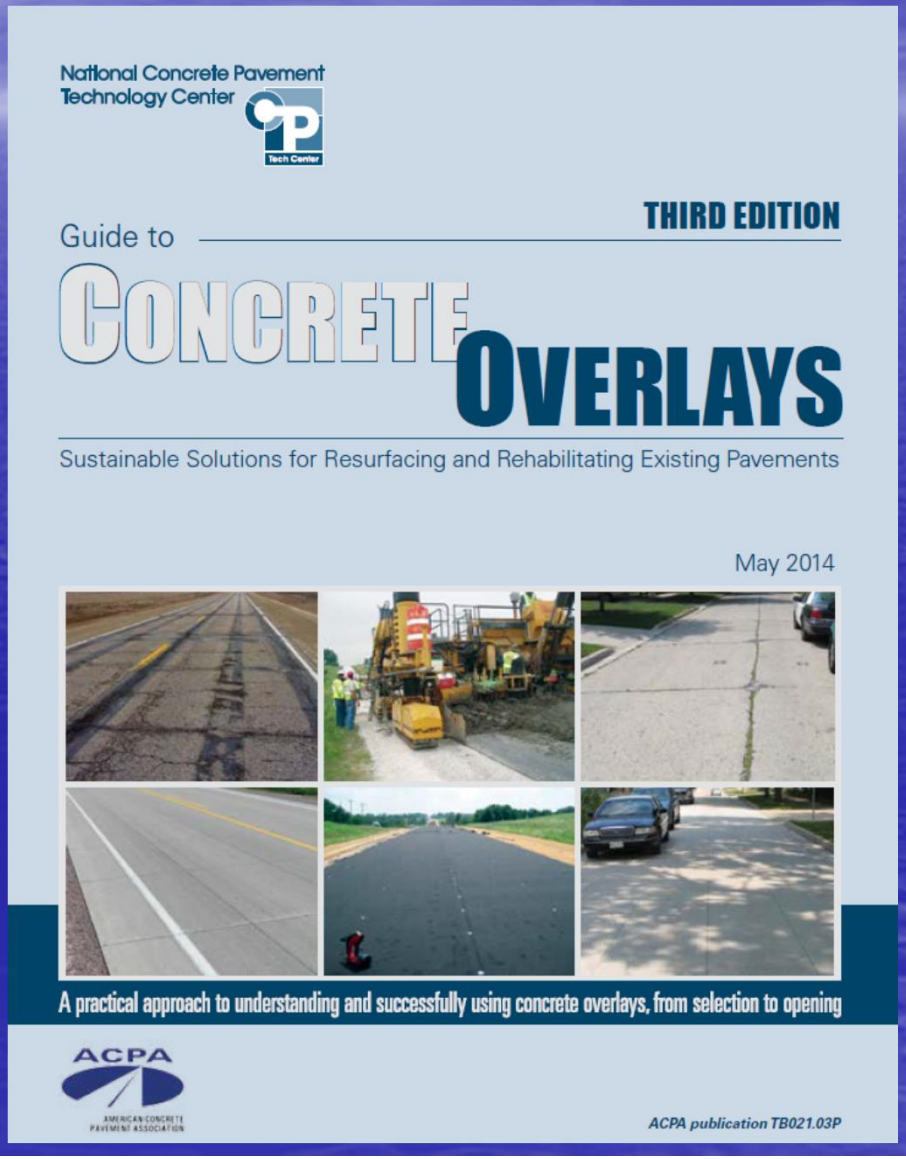
Source: http://www.cptechcenter.org/projects/overlays/index.cfm

Concrete Overlay Design methods used in Maryland (SHA)

- Bonded Concrete Overlay's
  - Bonded Concrete Overlay on Asphalt (BCOA) Thickness Designer developed by ACPA.
  - StreetPave developed by ACPA.
  - Illinois DOT's spreadsheet for Bonded Concrete Inlay/overlay of asphalt design.
  - AASHTOware 1993/1998(Darwin).
  - Bonded Concrete Overlay over Asphalt Mechanical-Empirical (BCOA-ME) procedure developed at the University of Pittsburgh.
  - MEPDG.
- Unbonded Concrete Overlay's
  - Maryland State Highway Administration (SHA) has not performed any Unbonded Concrete Overlay's.

Resources and References





Questions and Answers

Overview

- History of Concrete Overlay in MD
- Completed Projects in MD
- MOT – Lessons Learned
- Concrete Overlay Database
- Questions and Answers

Introduction

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- Director of Transportation Engineering at DFI Engineering
- Former Division Chief at MDSHA for Concrete Technology Division
- Bachelor in Civil from University of Bombay
- Master in Civil from University of Toledo, Ohio
- 21 years in Industry for Design and Construction
- 15 years in Private and 6 years with MDSHA
- Phone No.: 410-908-0403
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History of Concrete Overlay in MD

- Original Concrete Pavement and subsequently overlaid with Asphalt
- Not a Long History of Concrete Overlay until 2006
- Pilot Project – Anne Arundel County – MD 3 at Cronson Boulevard – 2006

Completed Projects in MD

- MD 3 at Cronson Boulevard – 2006 (Grind 6” HMA and 6” Concrete Overlay)
- Benfield Boulevard Park and Ride Lot – 2010 (Grind 3” HMA and 3” Concrete Overlay)
- US 40 near MD Portable Mix Concrete Plant – 2011 (Grind 6” HMA and 6” Concrete Overlay)
- MD 355 at MD 27 – 2012 (Grind 6” HMA and 6” Concrete Overlay)
- US 50 at US 301 – 2013 (Grind 6” HMA and 6” Concrete Overlay)

Completed Projects in MD

- I-68 Truck Climbing Lanes – 2014 (Grind 6” HMA and 6” Concrete Overlay)
- MD 2 at MD 214 – 2016 (Grind 6” HMA and 6” Concrete Overlay)
- MD 182 – Bus Stop Pads – 2016 (Grind 6” HMA and 6” Concrete Overlay)
- MD 210 NB from MD 373 to Farmington Road – 2015 (Grind 4” HMA and 6” Concrete Overlay)

MOT – Lessons Learned

- Lane Closures
- Nearby State or County Roads for Detour
- Partial shutdown
- Full shutdown
- Public Relations
- Joint Layout
- Finalize MOT Plan at Planning Stage or before Preliminary Investigation
- Potential Utilities
- District/Downtown/ACPA/Construction/ Traffic – Partnering

MD 3 at Cronson Boulevard – 2006

(Grind 6” HMA and 6” Concrete Overlay)

Concrete Overlay Pictures

During Construction

Concrete Overlay Pictures

After Construction

Concrete Overlay Pictures

EXISTING ROADWAY 2017

Concrete Overlay Pictures

EXISTING ROADWAY 2017

Lessons Learned

- Large Number of Cores – Mainline and Shoulder
- Intersection Box
- Maturity Meter
- Include Joint Layout in the Contract Document
- Potential/Future Utilities within the Project Limits
- Extra Care for Concrete Curing – Barricade
- Uneven subgrde support

Benfield Boulevard Park and Ride Lot – 2010

(Grind 3” HMA and 3” Concrete Overlay)

Concrete Overlay Pictures

Concrete Overlay Pictures

Concrete Overlay Pictures

Lessons Learned

- MOT – During the weekend – Less commuters
- Ultrathin Concrete Overlay
- Match-cure helps
- Plastic Shrinkage Cracks

US 40 near MD Portable Mix Concrete Plant – 2010

(Grind 6” HMA and 6” Concrete Overlay)

Concrete Overlay Pictures

Concrete Overlay Pictures

Concrete Overlay Pictures

Concrete Overlay Pictures

Lessons Learned

- **Partnering with the Industry/Concrete Plant/MDSHA**

MD 355 at MD 27 – 2012

(Grind 6” HMA and 6” Concrete Overlay)

Concrete Overlay Pictures

Concrete Overlay Pictures

Concrete Overlay Pictures

Concrete Overlay Pictures

Concrete Overlay Pictures

Concrete Overlay Pictures

Concrete Overlay Pictures

Concrete Overlay Pictures

Concrete Overlay Pictures

Lessons Learned

- MOT
  - Lane Closure
  - Nearby SHA and County Roads for Detour
  - Partial Shutdown of the Intersection
- Number of Cores
- Include Joint Layout
- Potential Utility Cuts/Conduits

US 50 at US 301 – 2013

(Grind 6” HMA and 6” Concrete Overlay)

Concrete Overlay Pictures

Concrete Overlay Pictures

Concrete Overlay Pictures

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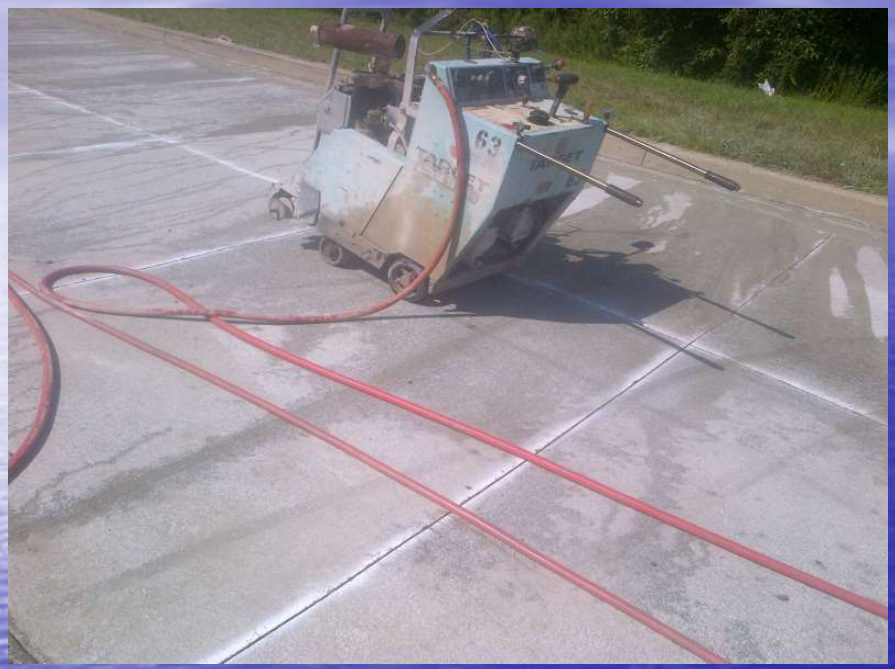


Concrete Overlay Pictures

Concrete Overlay Pictures

Concrete Overlay Pictures

Concrete Overlay Pictures

Lessons Learned

- Large Number of Cores – Mainline and Shoulder
- Include Joint Layout in the Contract Document
  - Joints in the wheel path
- Circular Ramps – Different widths from top to bottom
- Nearby routes as Detour

I-68 Truck Climbing Lanes – 2014 and 2017

(Grind 6” HMA and 6” Concrete Overlay)

Concrete Overlay Pictures

Concrete Overlay Pictures

Concrete Overlay Pictures

Lessons Learned

- Interstate Work
- Concrete pour on Incline
- Under lane closure
- Number of Cores
- Joints layout and saw cutting close to the Lane Markings
- Nearby Roads as Detour

MD 2 at MD 214 – 2015

(Grind 6” HMA and 6” Concrete Overlay)

Concrete Overlay Pictures

Concrete Overlay Pictures

Concrete Overlay Pictures

Lessons Learned

- MOT – State and County Roads for Detour
- Partial shutdown of part of the Intersection
- Under lane closure
- Areas not feasible for Concrete Overlay were full depth reconstruction
- Number of cores
- Joint Layout

MD 182 – Bus Stop Pads – 2015

(Grind 6” HMA and 6” Concrete Overlay)

Concrete Overlay Pictures

Concrete Overlay Pictures

Lessons Learned

- Reconstruction – Not necessary for Bus Pads
- Take cores specifically in the Bus Pad Area
- Savings – Time and Money
- Inconvenience reduced and lot safer
- MOT – State and County Roads Detour
- Partner with MTA
- Under lane closure
- Joint Layout

MD 210 NB from MD 373 to Farmington Road – 2015

(Grind 4” HMA and 6” Concrete Overlay)

MOT Challenges

MOT Options

1. **Closure of the Roadway over weekends**
   - **Detour was not practical**

2. **Double Lane Closure – Maintain one lane during weekends**
   - **Longer Construction Duration**
   - **Longer queues**
   - **Weekend weather constraints**

3. **Double Lane Closure – Counting outside shoulder as lane (7 days/week)**
   - **Shorter construction duration**
   - **Less queue than Option 2**

MOT Challenges

MOT Option 3 was selected

- **Less Queue**
- **Shorter Construction Duration**
- **Phase 1 – Slow Lane and Outside Shoulder to be Closed. Maintain Traffic on the Existing Middle and Fast Lane**
- **Phase 2 – Fast Lane and Middle Lane to be Closed. Maintain Traffic on the already Constructed Slow Lane and Outside Shoulder**

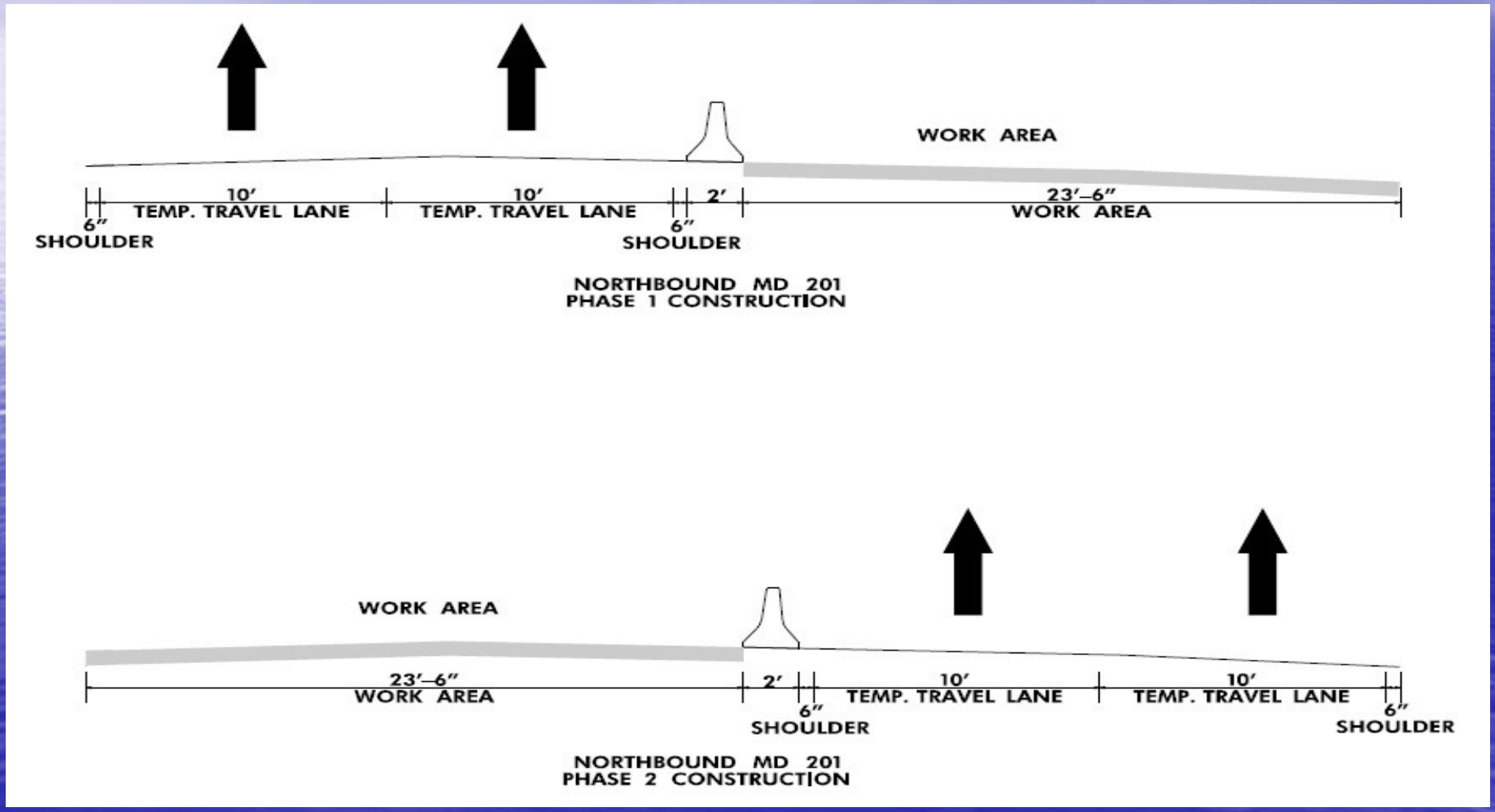
MOT Challenges

Other Challenges

- **Concrete Construction Barrier**
- **Getting Saw Cut Joints close to the Final Lane Markings**
- **Heavy PR campaign from SHA**

MOT Challenges

Typical for MOT Phase 1 and 2



Construction Challenges

- Tight Schedule – 6 weeks for Concrete Operation
- 26,000 square yards of Concrete Overlay (4400 LF)
- Limited Road Width and Congestion
- Saw Cut Joints Close to Final Lane Markings
- Unknown Subgrade Conditions

Project Highlights/Achievements

- First Long Concrete Overlay Project
- Completed ahead of Schedule
- AASHTO Award – Under Budget Category
- Paving Performance
  - Average IRI – 43
  - Number of Defect Sections – 0
  - Ride Profile Incentive – $19,257
- Concrete Performance
  - No of Failing Cores – 0
  - No of Failing Strength Cylinders – 1 of 250+

Concrete Overlay Pictures

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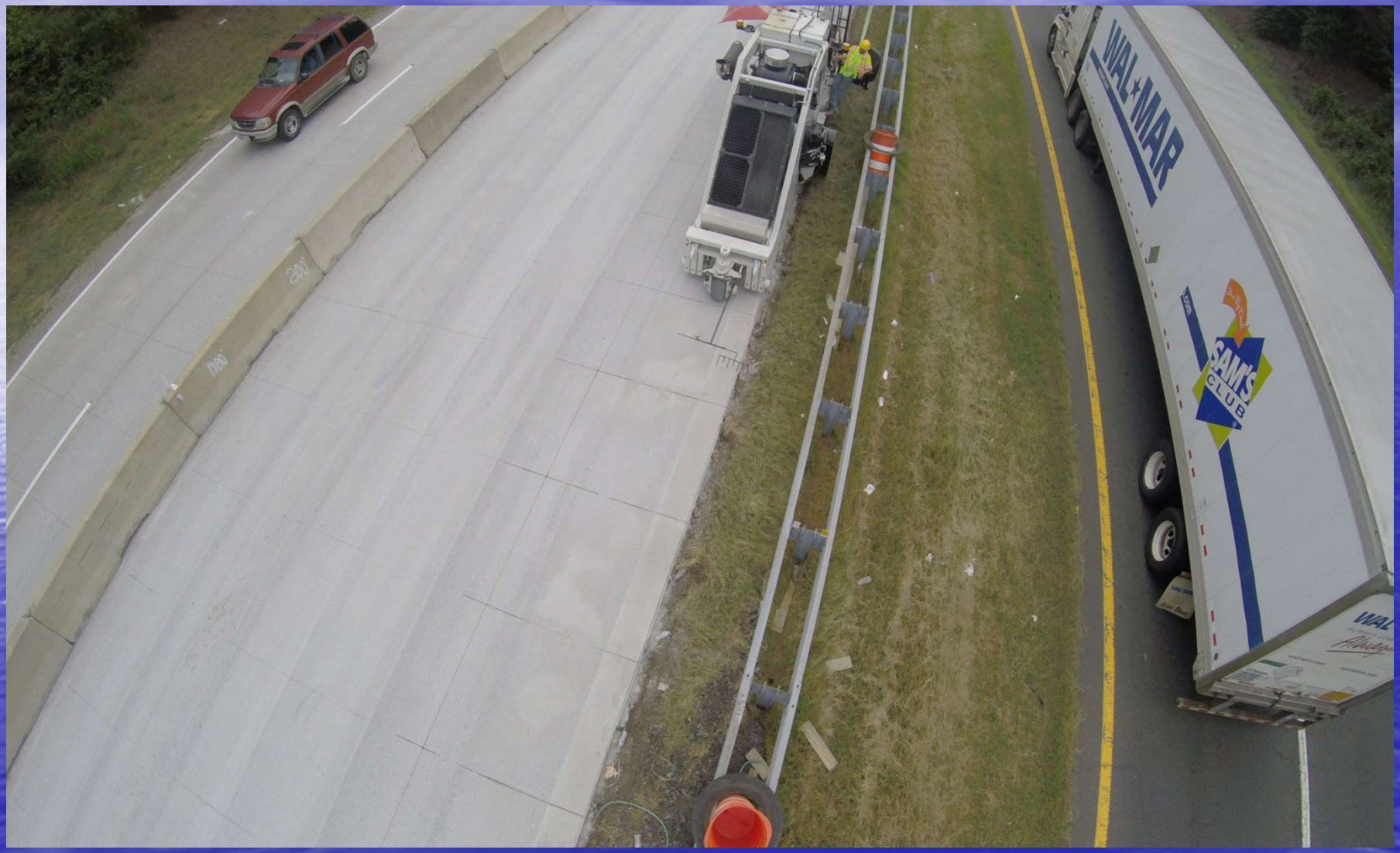

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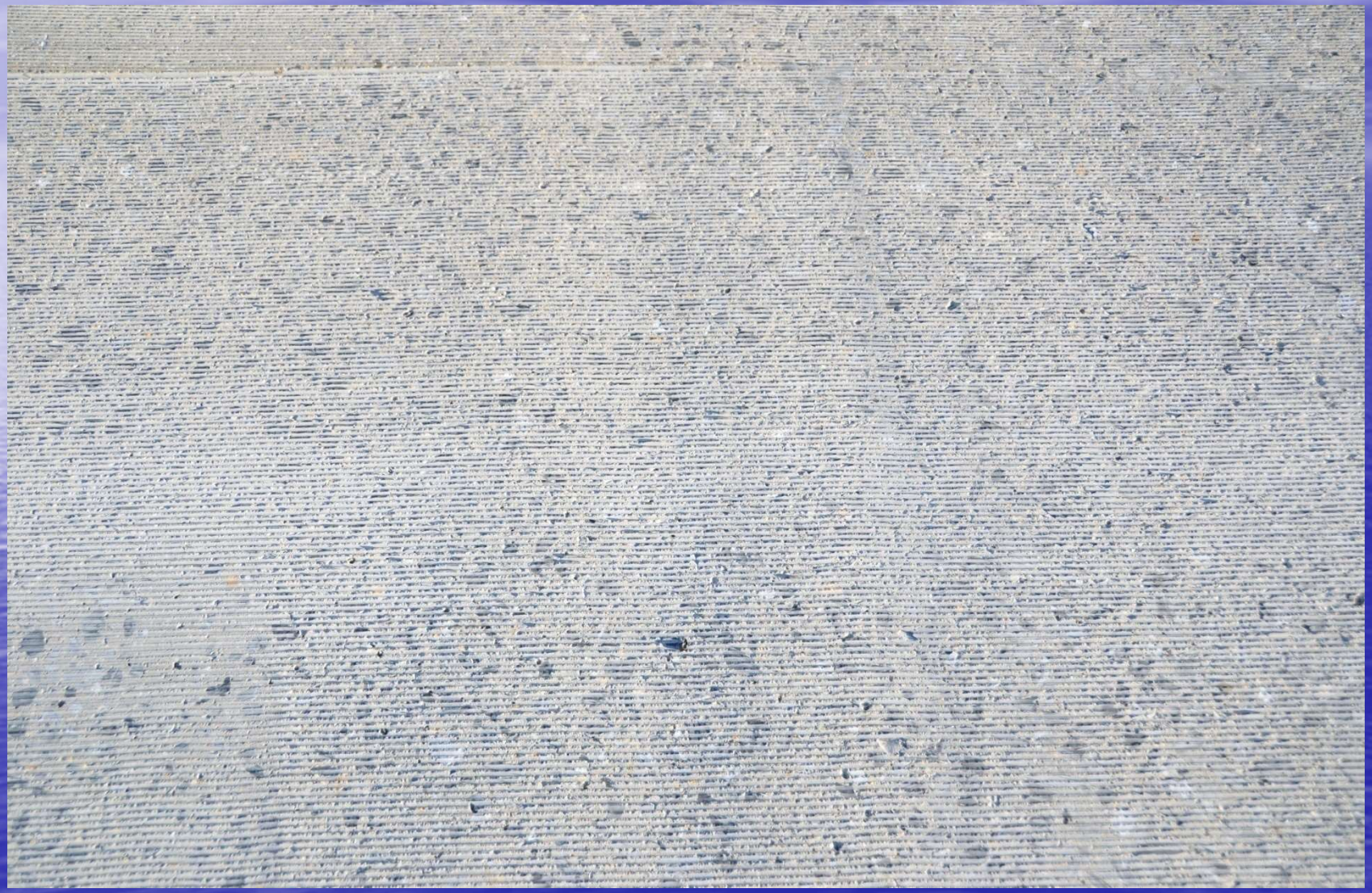

Lessons Learned

- Large Number of Cores – Mainline and Shoulder
- Include Joint Layout in the Contract Document
- Potential/Future Utilities within the Project Limits
- The Queue Length was not as long as predicted
- PR Campaign helps (may be the reason for less Queue Length)
- Limited Road Width and Congestion
- Saw Cut Joints Close to Final Lane Markings
- Unknown Subgrade Conditions

Concrete Overlay Database

- Nationwide Database for Concrete Overlays
- http://www.acpa.org/overlay-explorer/

Questions and Answers