Texas A&M Transportation Institute

Developing FDR Sections with In-House Resources

Product 0-6880-P11

Project Title: Full Depth Reclamation in Maintenance Operations Using Emerging Technologies

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Objectives

- Describe the steps necessary for properly developing an FDR candidate project
- Identify which department's resources are required
- Explain procedures required to successfully start FDR construction

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Part I

Why FDR

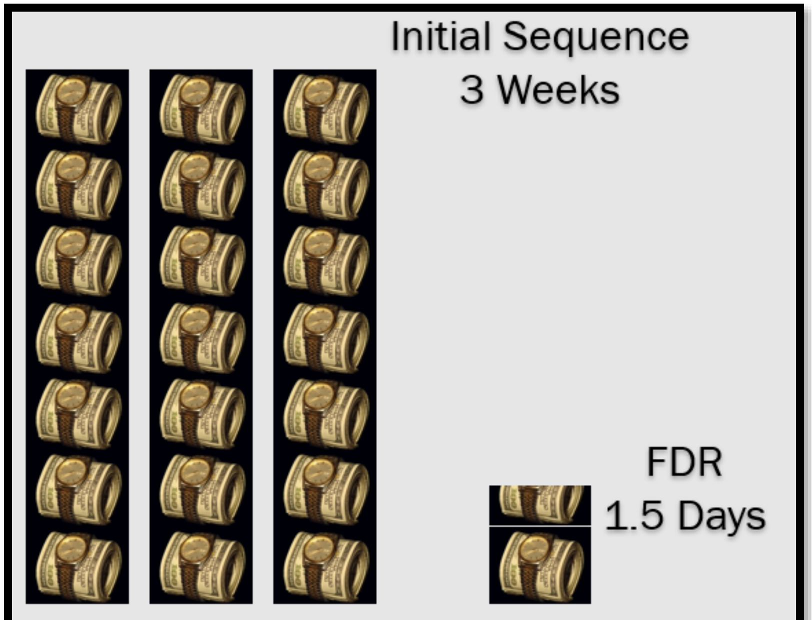
Why FDR

- Save time
  - Up to ¾ lane-mi./day
- Open to truck traffic day of treatment
- Save $
  - 50% cost reduction
- Upgrade and reuse marginal materials

Is this a candidate…?

Proper project selection is key

Benefits of FDR



Significantly reduce construction time

Generally up to ~ ¾ lane-mi. per day

Benefits of FDR

- Cement: ~ $5 / SY
- Foamed asphalt: ~ $10 / SY
- Emulsion: ~ $13 / SY
- Thick mill/inlay or reconstruction strategies
  - ~ $30 - $40 / SY

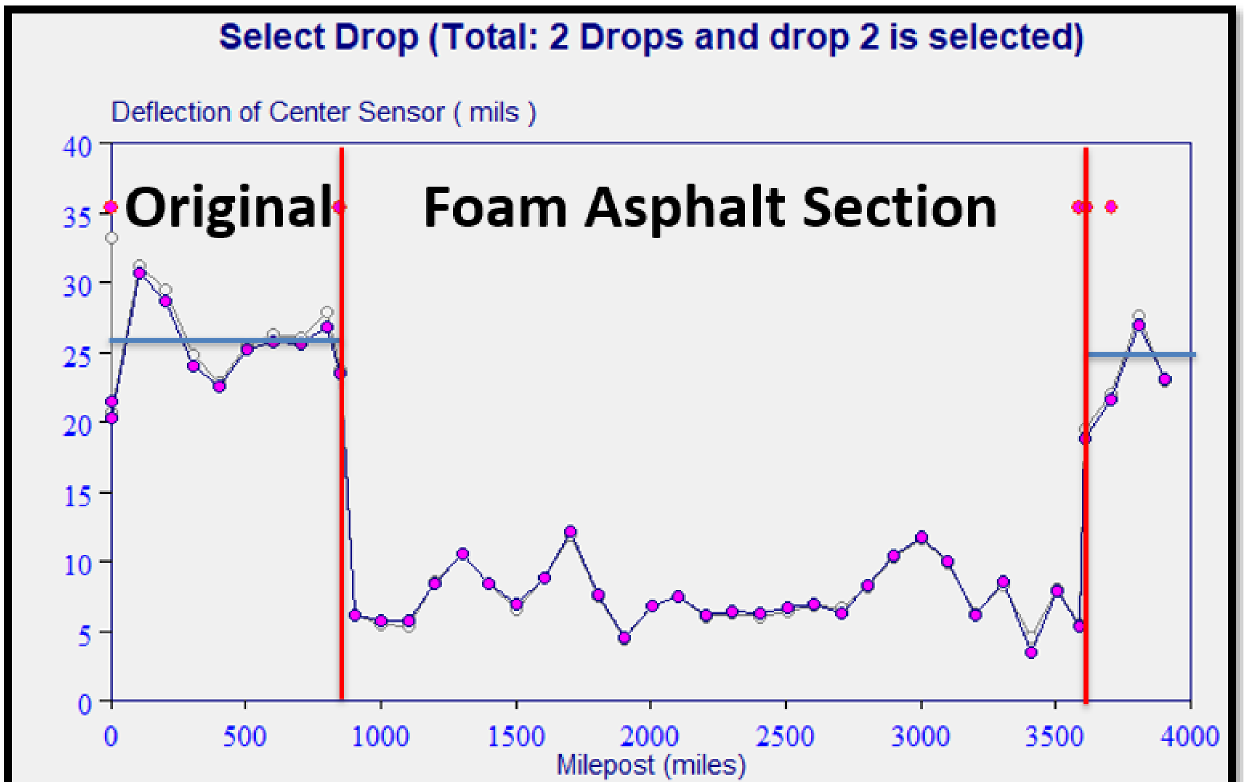
~ 50% or more cost savings by using FDR

Why FDR with Asphalt

- Fast construction: ¾ lane-mile per working day
- Early opening to traffic: generally stable under same-day traffic with minimal raveling
- High stiffness base: 200 ksi design modulus means longer pavement life and/or reduced final surface thickness requirement compared to CTB
- No shrinkage cracks: strong, durable moisture-resistant base without shrinkage cracking

Truck traffic on FDR section (foam) with fog seal applied

Benefits of FDR



Poor-quality existing base upgraded to moisture-resistant layer with low deflection

Solid core 6 mo. after FDR

What makes a good FDR Candidate?

- Pavement with base problems
  - Inadequate thickness
  - Loss of stabilized layer
  - Moisture-susceptible materials
- Pavements not structurally adequate
  - Increasing traffic loads
  - Energy sector
- Pavements with major edge failures
  - Needing widening

What does not make a good Candidate

- If distress is surface-only
  - ex: de-bonded HMA
- If distress is primarily due to subgrade
- Stripped HMA
  - May or may not be good candidate, depending on depth to stripping, current traffic, and quality of base

Upfront testing determines if a project is a good candidate

Steps to Develop FDR

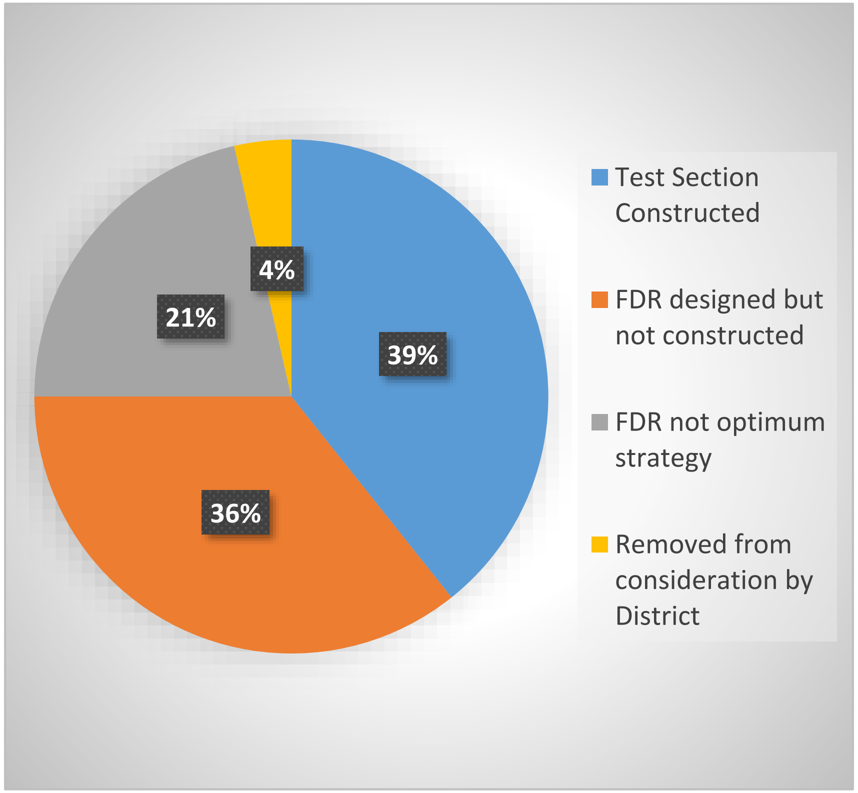
Activity	Typical Duration
Upfront site evaluation and sampling	6 weeks
Pavement design[1]	4 weeks
Lab mix design[1]	4 weeks
Procurement of oil and other materials	3.5 months
Mobilization	3 weeks
FDR process	0.5 lane-mi. per working day

[1]Pavement and mix design generally occur concurrently and must coordinate with upfront site evaluation.

Must perform upfront selection and design work to properly select projects prior to construction

Overall Project Selection Success Rate

- About 75% of sections nominated are viable
- Critical to screen out the 25% that are not good candidates



Summary FDR selection outcomes from TxDOT Research Project 0-6880

Part II

Upfront Testing

Upfront Testing

- Project history
- Soils maps
- GPR
- FWD
- Sample materials
- Determine existing typical section(s)

Purpose of Upfront Testing

- Identify what is the cause(s) of distress
- Identify existing typical section(s)
- Guide selecting potential pavement and mixture design options

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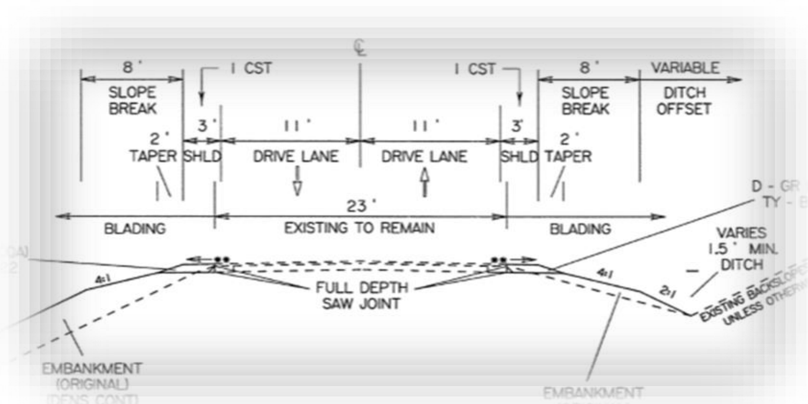
Tools for Upfront Testing

What do we know?	What do we need?
Existing typical sections Soils maps MNT history	GPR FWD DCP Coring/drilling Roadway sampling



? =

Is the typical section still accurate?

Sampling Approaches

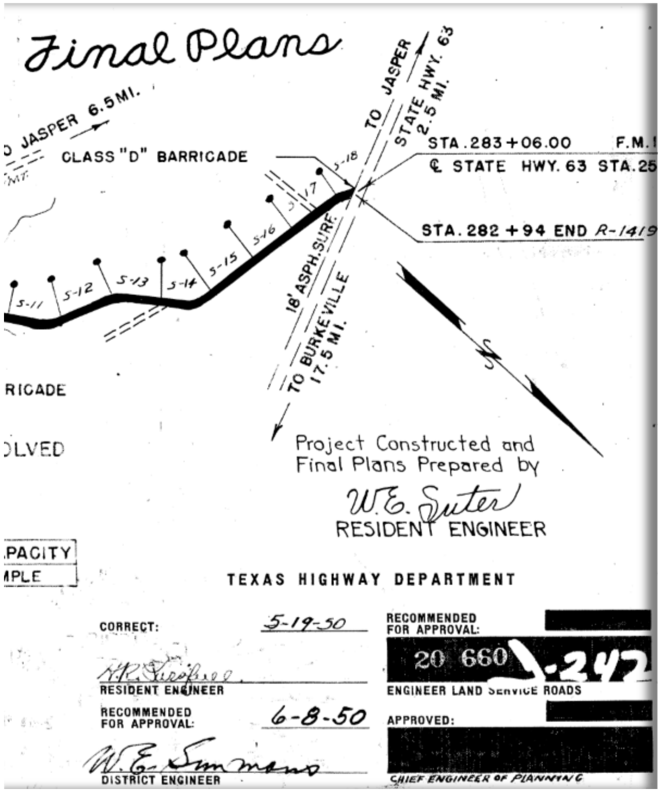
Step	Recommended Approach	Acceptable Approach
1	Obtain historic plans. Conduct a ground-penetrating radar (GPR) survey.	Obtain plans and maintenance history.
2	Using plans and the GPR survey, determine critical locations for sampling. Cover the expected range of recycled asphalt pavement (RAP) and total pavement thickness.	Unless otherwise determined from plans and maintenance history, perform drill logs at 1-mile spacing of the pavement structure including at least the top 10 inches of subgrade. For short projects (< 1 mile), sample and log a minimum of three locations.
3	Sample and log each location to include at least the top 10 inches of subgrade.	Review drill logs. Select locations representing significantly different materials for follow-up bulk sampling.
4	At each location of significantly different materials, use a small recycler or auger to obtain samples of materials expected in the road mix. Typically, the top 8 to 10 inches of pavement contain these materials.	At each location of significantly different materials, use a small recycler or auger to obtain samples of materials expected in the road mix. Typically, the top 8 to 10 inches of pavement contain these materials.
5	If RAP exceeds 2 inches in the existing pavement, maintain the RAP and salvage base separately.	If RAP exceeds 2 inches in the existing pavement, maintain the RAP and salvage base separately.
6	Collect approximately 400 pounds of sample for each set of different materials requiring a mixture design.	Collect approximately 400 pounds of sample for each set of different materials requiring a mixture design.

Excerpt from Treatment Guidelines for Soils and Base in Pavement Structures, *August 2019*

TxDOT Materials and Tests Division

Existing Typical Sections

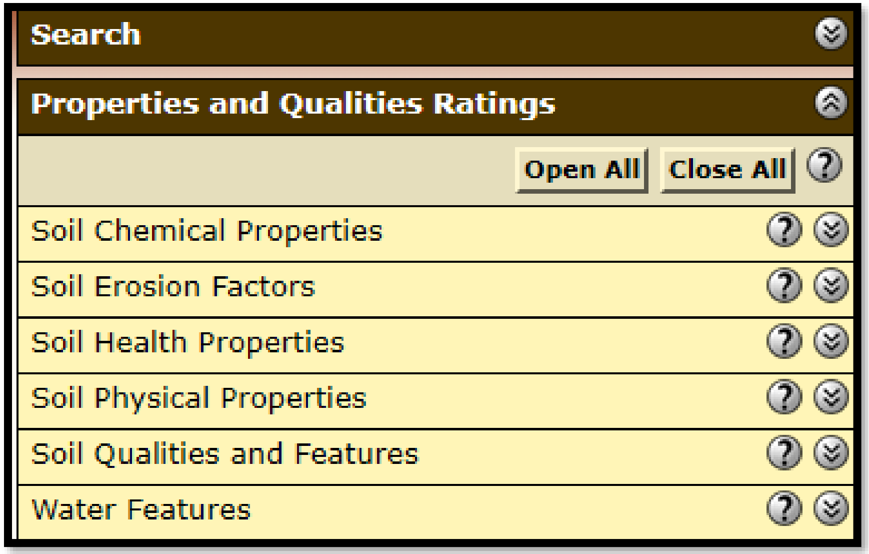
- A starting point
- Often dated
  - May or may not be very representative
  - Do not track maintenance history
- Need confirmation through field testing



Soils Maps

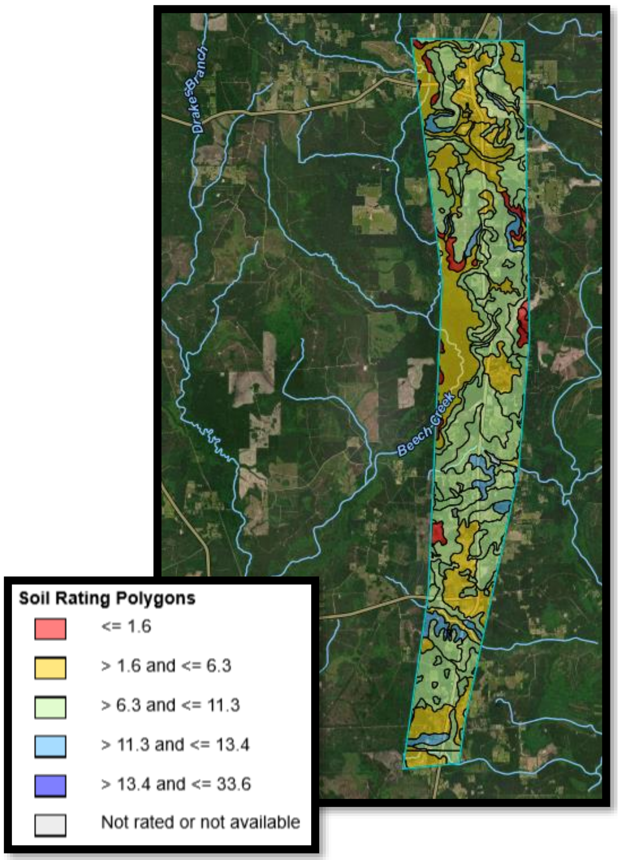
- Available online

- Examine expected plasticity index and sulfates
- Other data is also available online

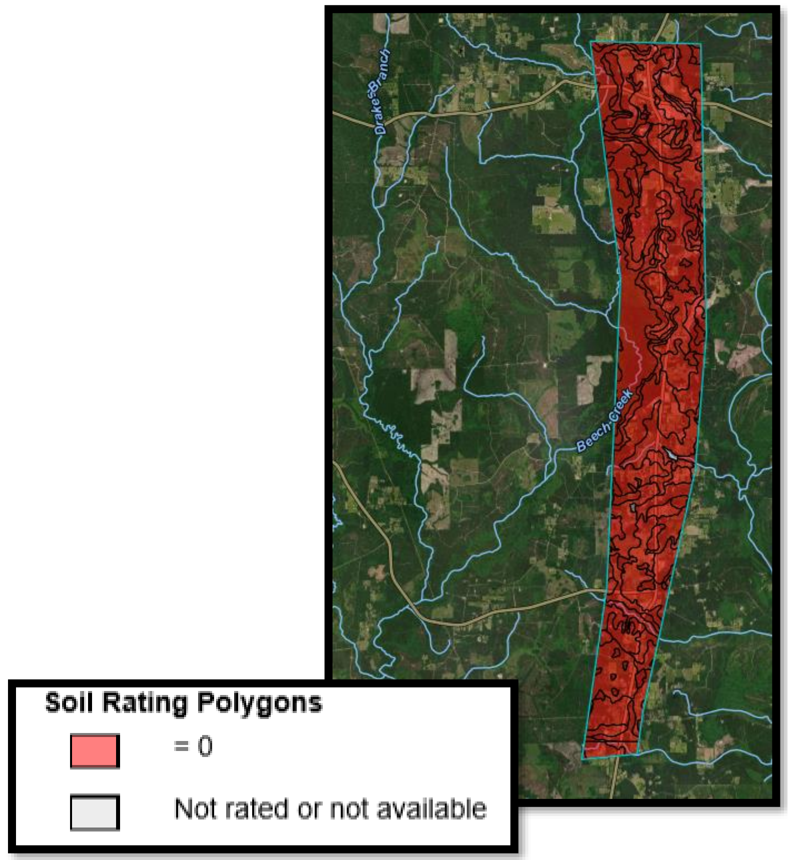


- *Find gypsum ratings under chemical properties*
- *Find plasticity index in physical properties*

Example Soils Maps



PI generally < 11



Expected gypsum-free

Maintenance History

- What is the maintenance history?
- Has road been widened?
- Level-up activity?
- Patching? What method(s)?
- What material(s) has(have) maintenance section encountered when working on section?

Nondestructive Tests and Sampling

NDT

- Supports forensic investigation
- Helps make smarter decisions for focused sampling
- Examines for defects that may be unseen
- Identifies pavement layer properties

Sampling

- Confirms existing pavement structure(s)
- Can help confirm cause(s) of distress
- Generates materials for required lab tests

NDT Pavement Evaluation Tools

- Identify section breaks
- Characterize pavement layers
  - Variability
  - Base and subgrade modulus
- Does not eliminate but makes smarter sampling

GPR

FWD

DCP

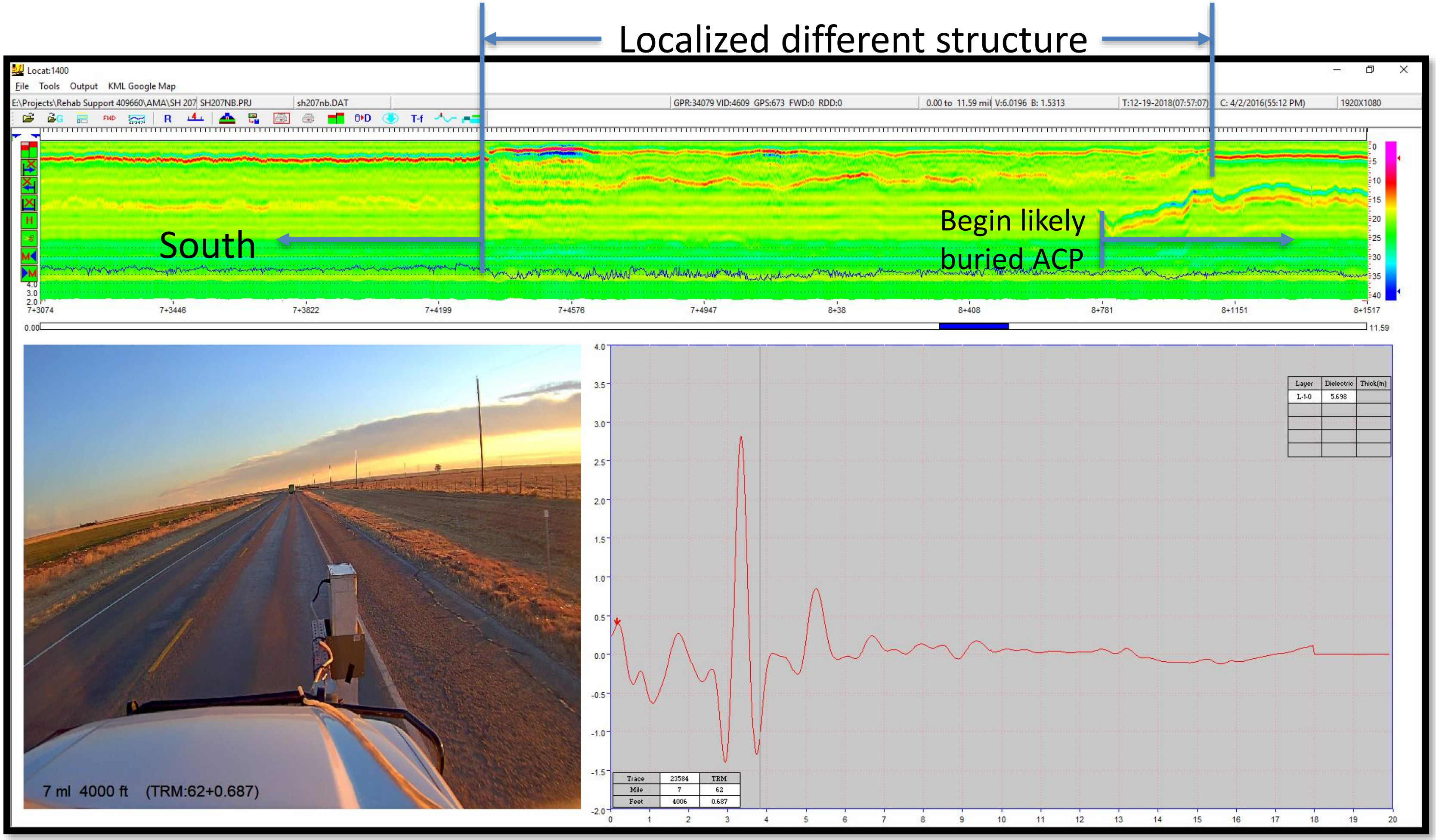
GPR

- Nondestructively scans the pavement with no traffic control
- Sees into pavement using radar signal
- Can identify irregularities or potential defects

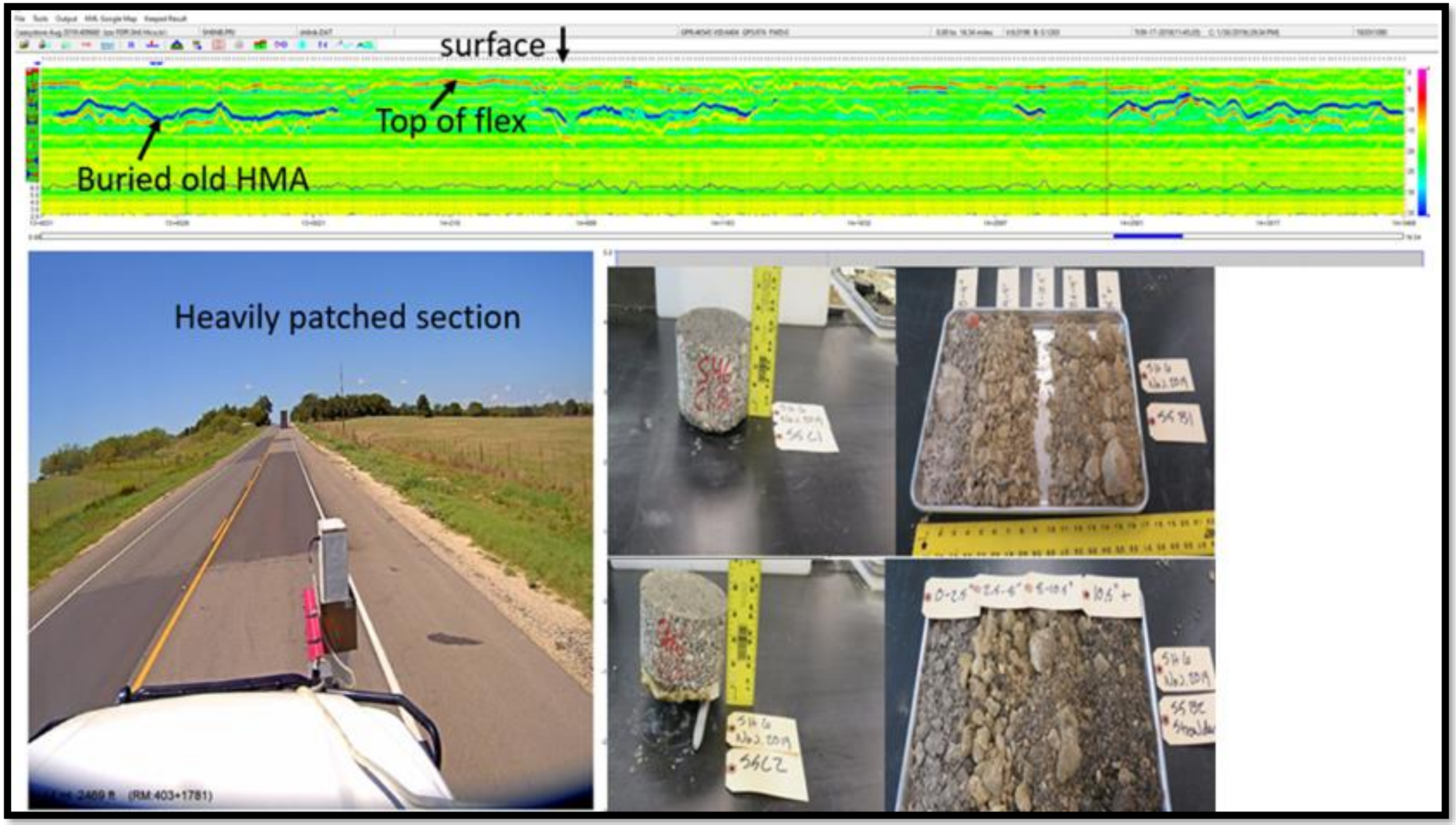
Assistance available —
contact Roberto Trevino Flores at MNT

One of TxDOT's GPR vans

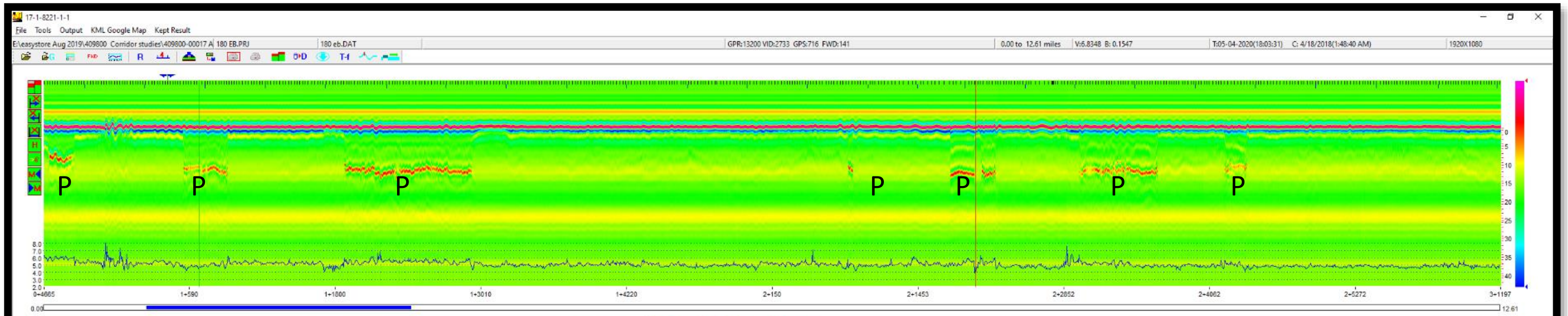
GPR for Identifying Sections



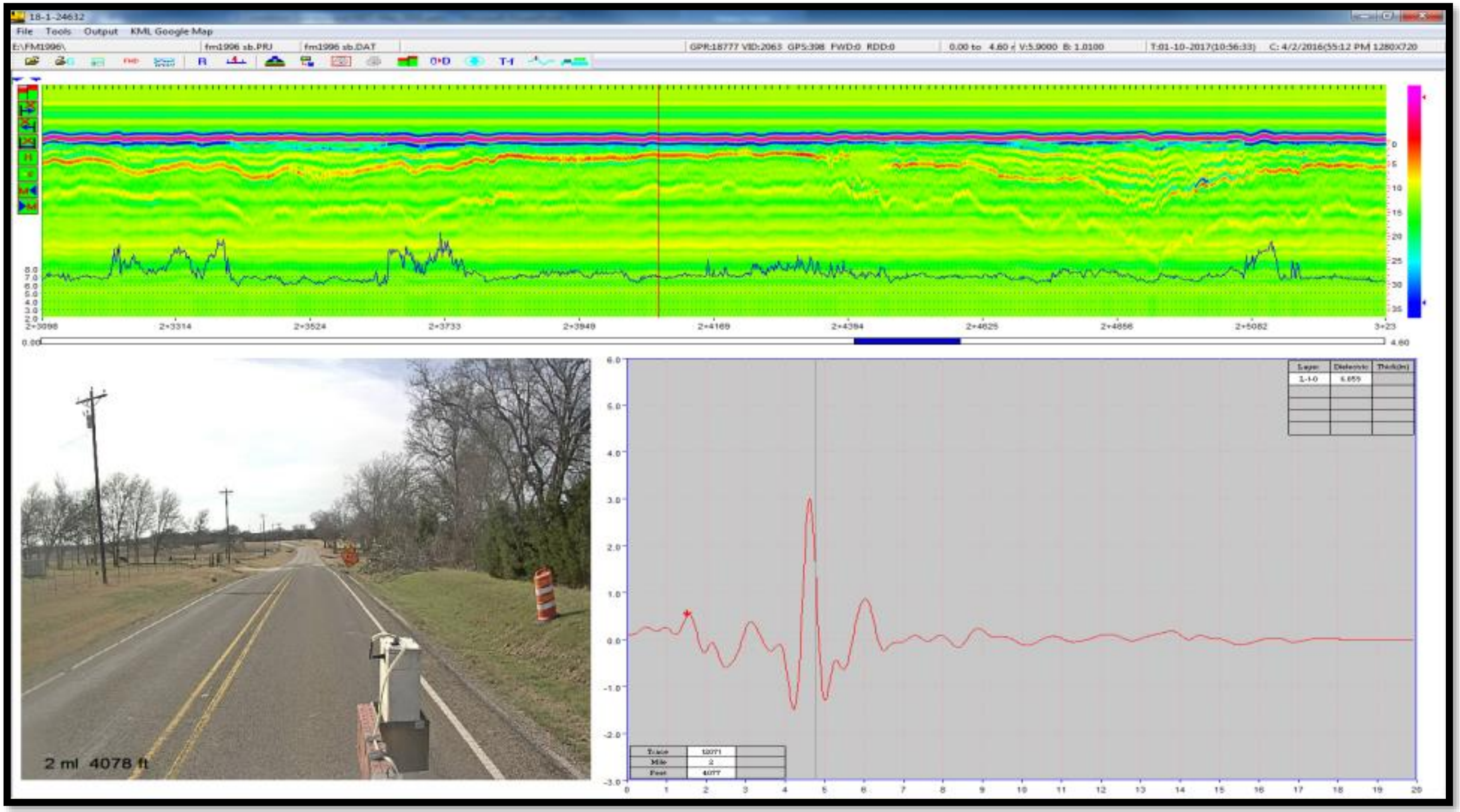
GPR for Identifying Sections



GPR for Identifying Sections – the Patchwork Quilt

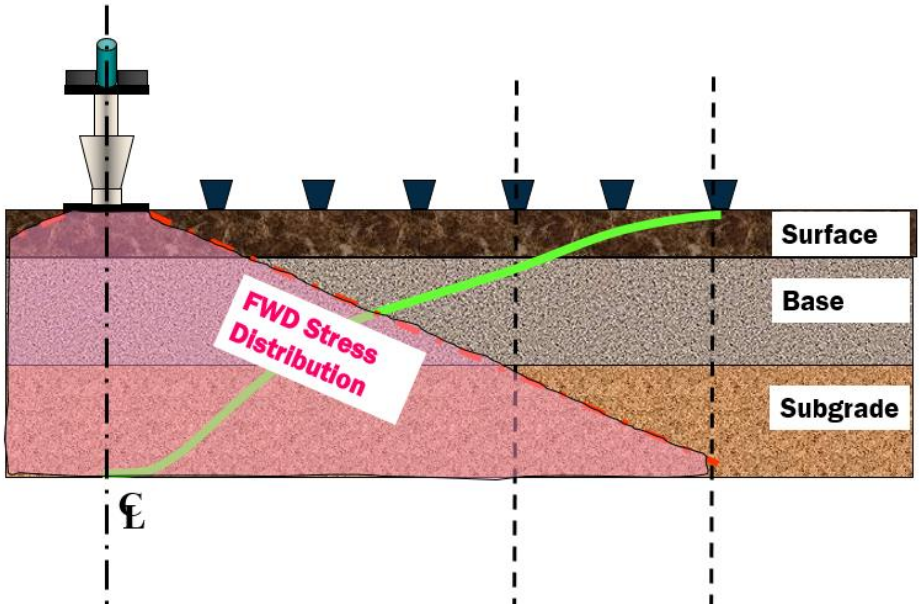


GPR for Emergency Mix Design



FWD

- Standard tool for in-place pavement strength measurement
  - Measures deflection
- Nondestructive
- Requires TCP



General principle of FWD operation

Assistance available — contact MNT

Closeup of FWD Unit

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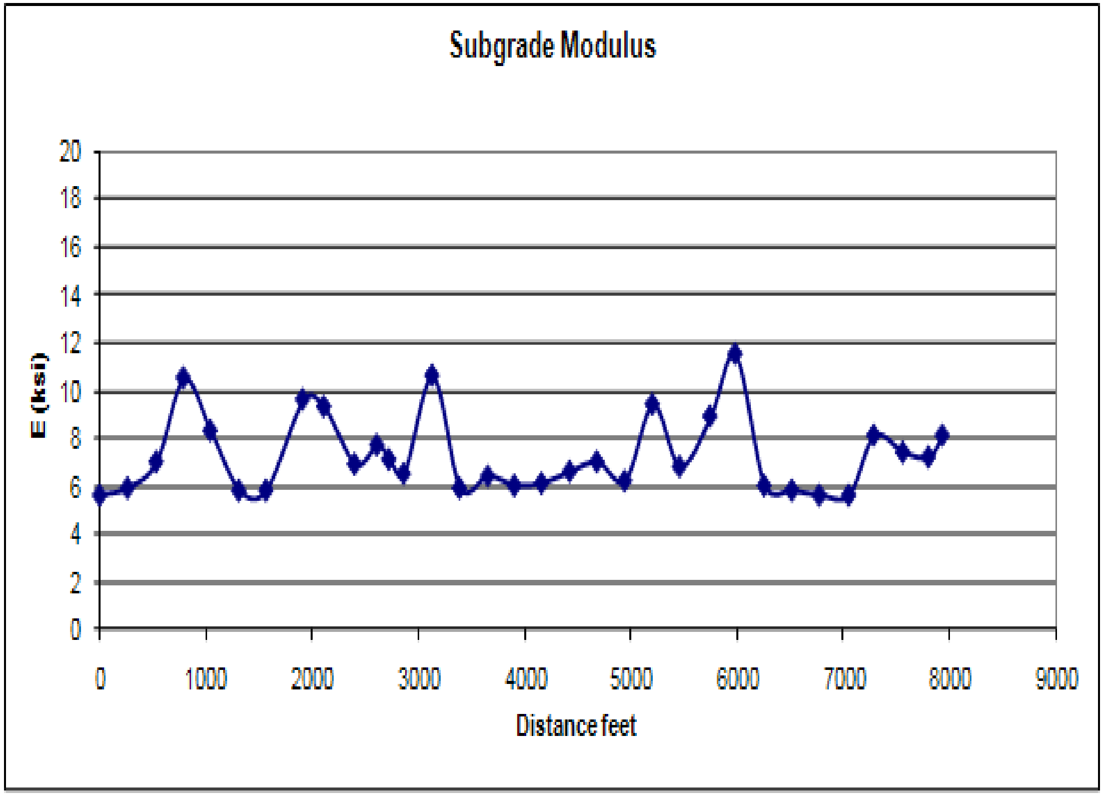
Example FWD Output



FWD to obtain subgrade modulus for design

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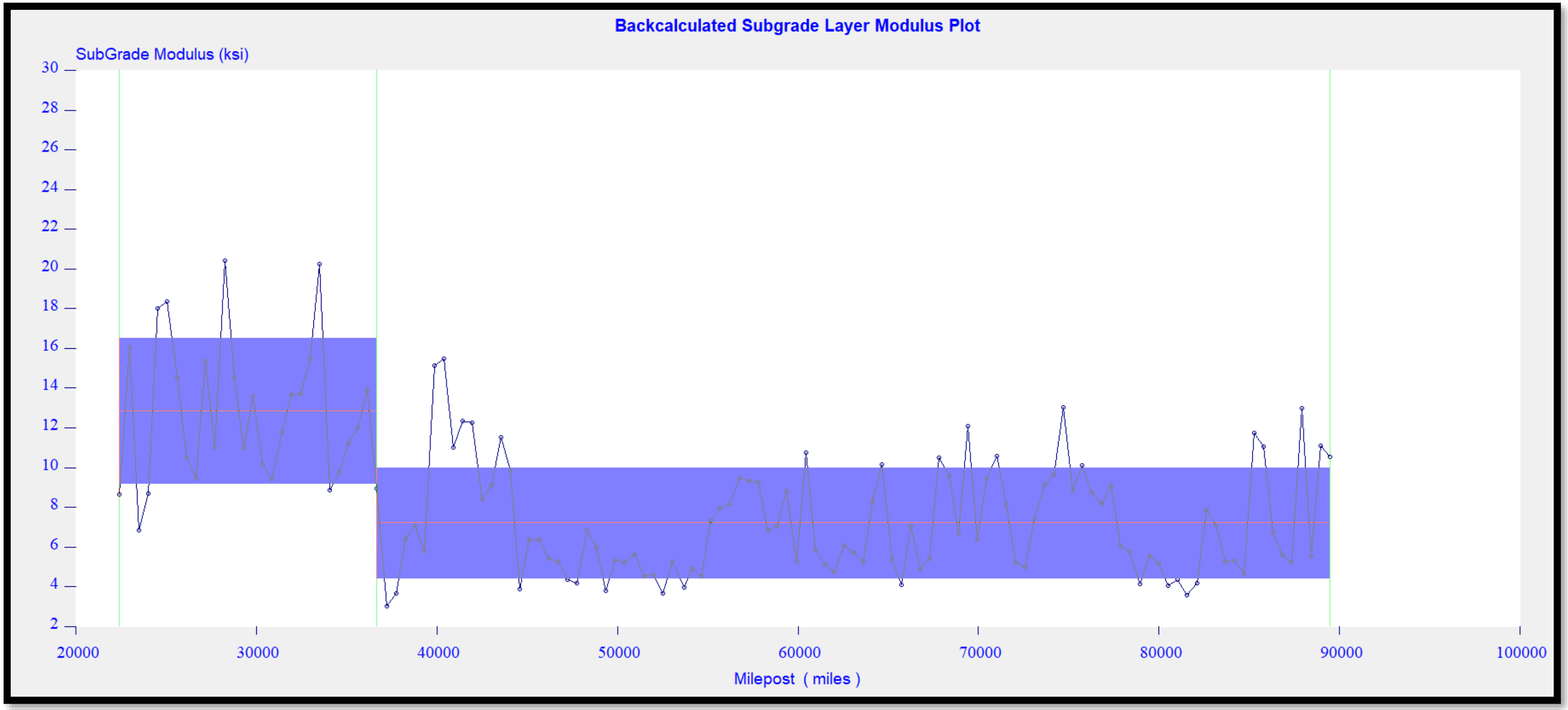
Example Segmentation of Project by FWD



DCP

- Spot test, normally performed concurrent with sampling
- Drives pointed tip into the pavement base and subgrade layers using impact from a sliding weight
- Helps identify strength of base and subgrade
- Can estimate thickness

DCP kit

DCP Example

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Form DCP:

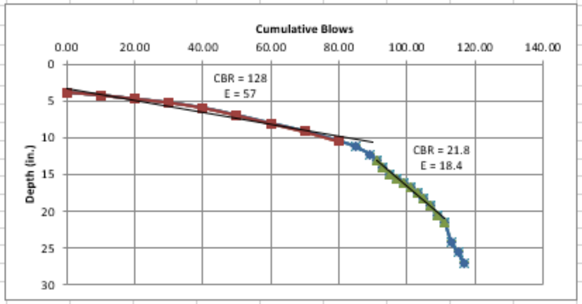
For use with DYNAMIC CONE PENETROMETER TESTING

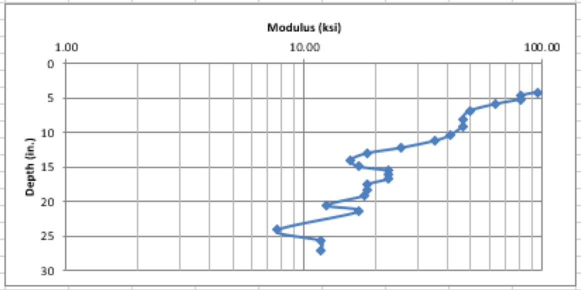
District		Location/Site Numb	3A OWP
Roadway	Example	Test Description	Non-widened
Test Date	6/11/2021	TRM	

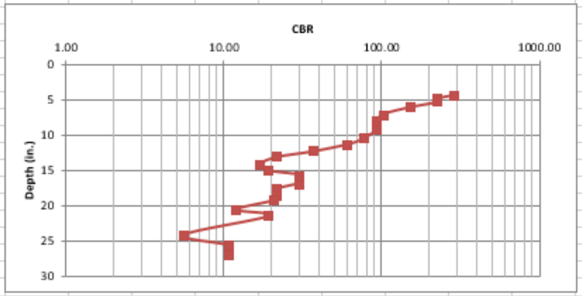
	Slope	Intercept	CBR	E (Ksi)
		Inches		
Surface Zero		0.9		
Layer 1	0.0823	3.17	127.8560471	56.86457471
Layer 2	0.3986	-23.26	21.8457681	18.35419176
Layer 3				

Site Photo

# Blows	Penetration (in)	Cumulative Blows	Cumulative Penetration	CBR	E (ksi)
0	4.7	0	3.80		
10	5.1	10	4.20	286.9	95.4
10	5.6	20	4.70	223.4	81.3
10	6.1	30	5.20	223.4	81.3
10	6.8	40	5.90	153.3	63.9
10	7.8	50	6.90	102.8	49.5
10	8.9	60	8.00	92.4	46.2
10	10	70	9.10	92.4	46.2
10	11.3	80	10.40	76.6	41.0
5	12.1	85	11.20	60.7	35.3
4	13.1	89	12.20	36.8	25.6
2	13.9	91	13.00	21.8	18.3
2	14.9	93	14.00	16.9	15.6
2	15.8	95	14.90	19.1	16.8
2	16.4	97	15.50	30.0	22.5
2	17	99	16.10	30.0	22.5
2	17.6	101	16.70	30.0	22.5
2	18.4	103	17.50	21.8	18.3
2	19.2	105	18.30	21.8	18.3
2	20.03	107	19.13	20.9	17.8
2	21.4	109	20.50	11.9	12.5
2	22.3	111	21.40	19.1	16.8
2	25	113	24.10	5.6	7.7
2	26.5	115	25.60	10.8	11.7
2	28	117	27.10	10.8	11.7







Roadway Sampling Tools

- Verify the existing structure/interpretation of NDT
- Obtain materials for use in the lab mixture design
- Experienced staff needed to document site conditions

Core rig

Drill rig

Milling attachment

Gradall

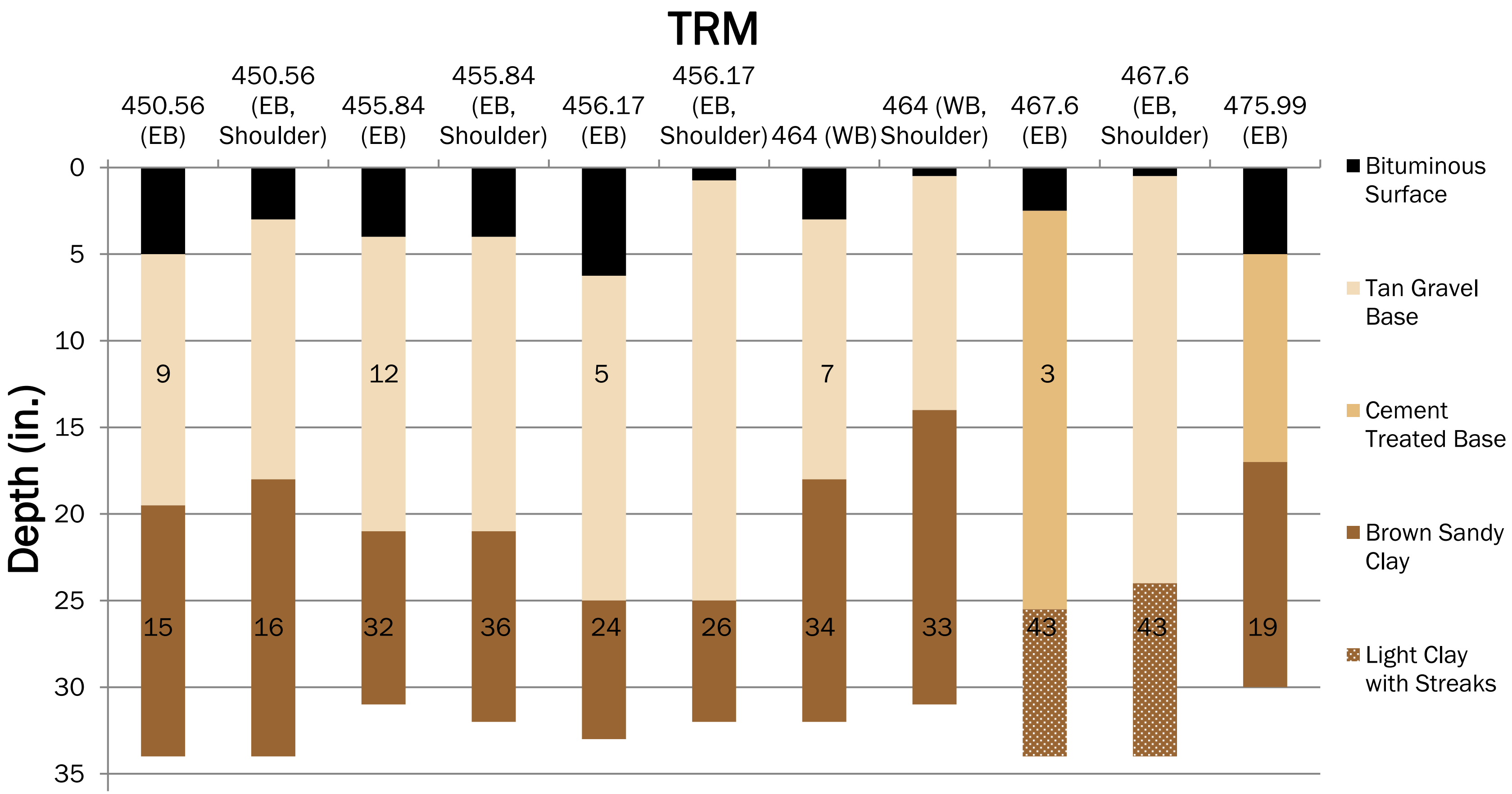
Example Materials Sampling

- Maintain dissimilar materials separately
- If ACP > 2 in. maintain separately
- Need to confirm cross section is uniform
  - May require sampling lanes and shoulders

Material nonuniformity must be captured and considered in mix design

Generating sample for mix design

Example Drill Log with Plasticity Index



Must use in combination with lab to select strategies, possible material combinations and treatment(s)

Why do all this Upfront Testing?

Rutting & cracking

Between wheel paths

Wheel path

TxDOT's 1st foamed asphalt project (2000): failures < 1 yr. old
Reclaimed 10"
Problem – locally only 7" of pavement over back clay
13-year delay until TxDOT willing to try again

Upfront testing helps avoid surprises

Part II Summary

Upfront Test Activity	Primary Responsibility	Comment
Project history	District	Plans, soils maps, maintenance history
GPR	MNT	Allows smarter coring
FWD	MNT/district	Needed for structural information
Roadway sampling	District/MNT/MTD	Make sampling plan based on NDT. Confirm structure and generate materials for lab.

Proper upfront testing is key for project selection.
Requires coordination of district, MNT and MTD.
Site info must collaborate with pavement structural and lab mixture design.

Part III

Pavement Design

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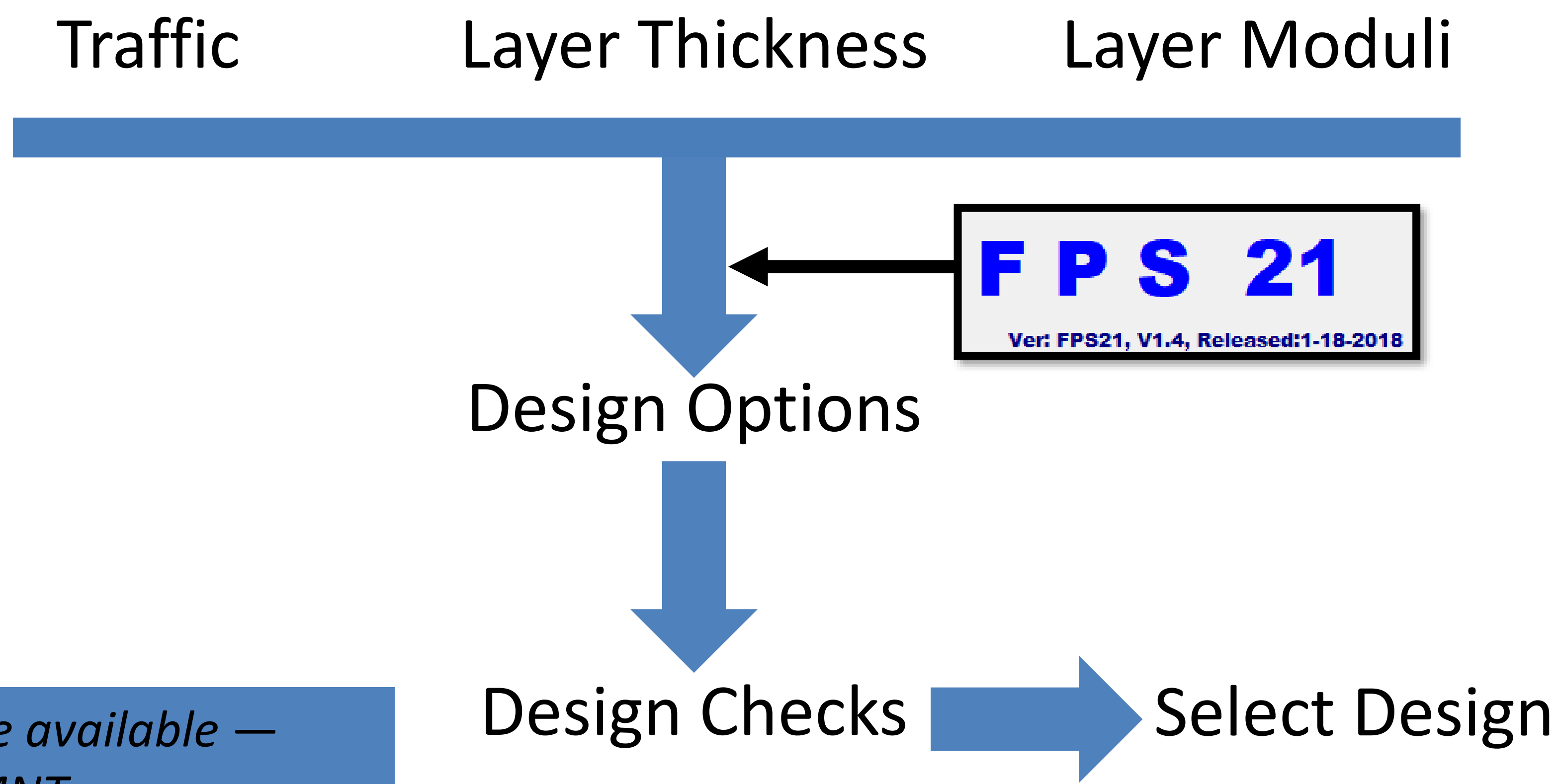
Lives, Time and Resources

Pavement Structural Design Must…

- Coordinate with upfront testing
- Use appropriate design inputs
- Coordinate with mixture design
- Balance cost, constructability and risk

General Steps for Pavement Structural Design



Assistance available — contact MNT

Key Inputs Needed for Structural Design — Traffic

- Generally obtained from traffic survey
- Estimates for state roads available on web
- **20-yr ESAL key**
- Counts may vary < 0.5 M to > 10 M
- **Projected industry or energy sector impacts**

Local industry strongly influences traffic requirements

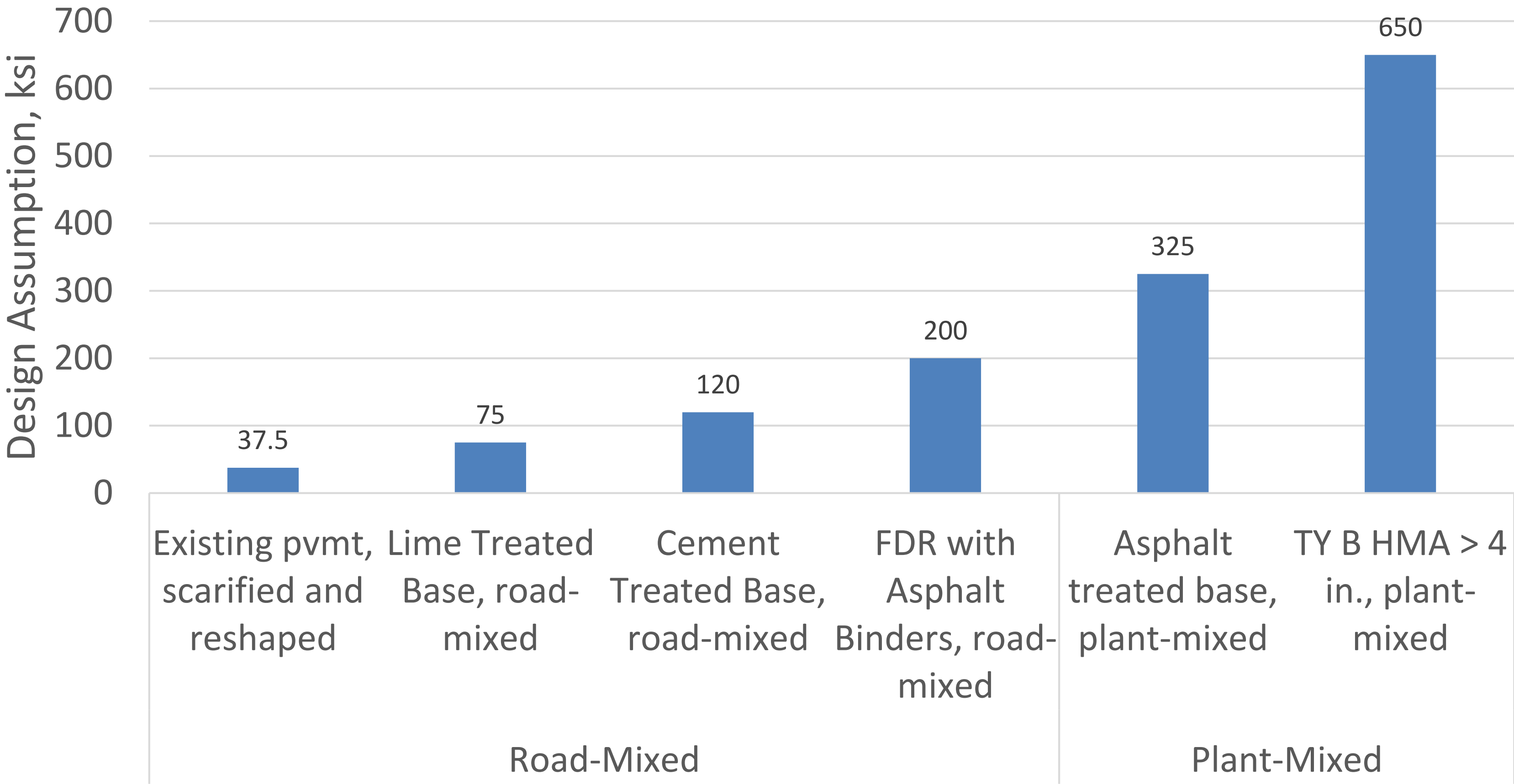
Key Inputs for Structural Design — Layer Thickness

- Need input from upfront testing
  - existing subbase (if present), base and surface layer thickness
- FDR layer and final surface layer thickness will generally be a thickness range in design program
  - Generally, minimum 8 in. recommended for FDR layer
  - Max. for FDR layer may be in excess of 12 in.
  - Final surface may be surface treatment or HMA

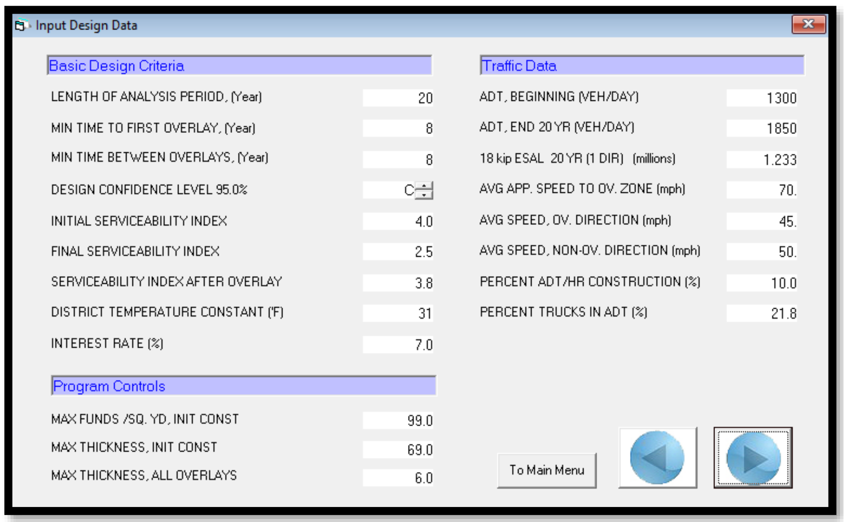
Considerations in FDR Layer Thickness

- Generally recommended FDR cut to at least 1" below existing ACP
- Do not want to introduce subgrade into FDR mixture
  - For low PI subgrade: allow minimum 1" buffer
  - For high PI subgrade: allow at least 2" buffer

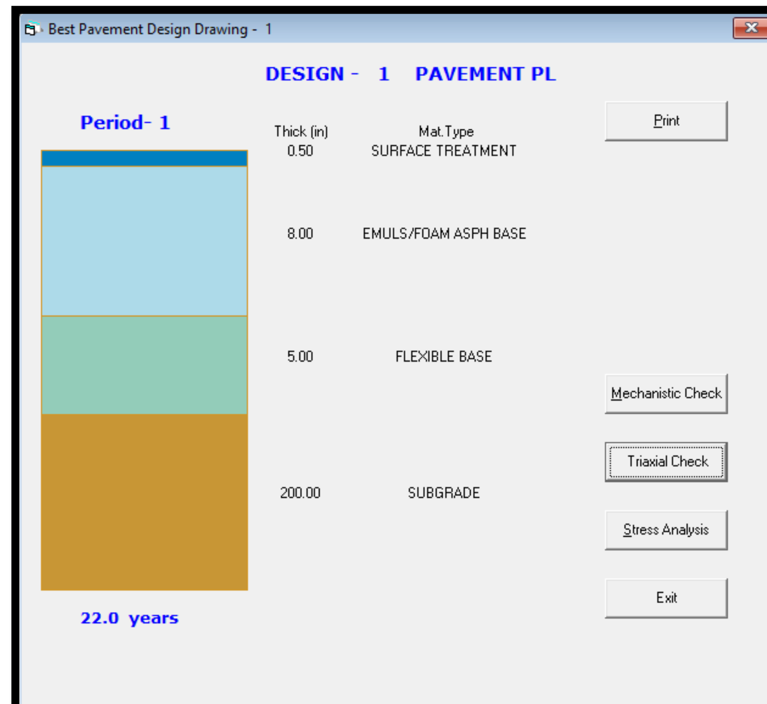
Typical Design Assumptions by Base Layer Type



Example Pavement Design Input and Output



Input: Defines analysis period, performance criteria and traffic



Output: presents design(s) meeting criteria and overlay policy

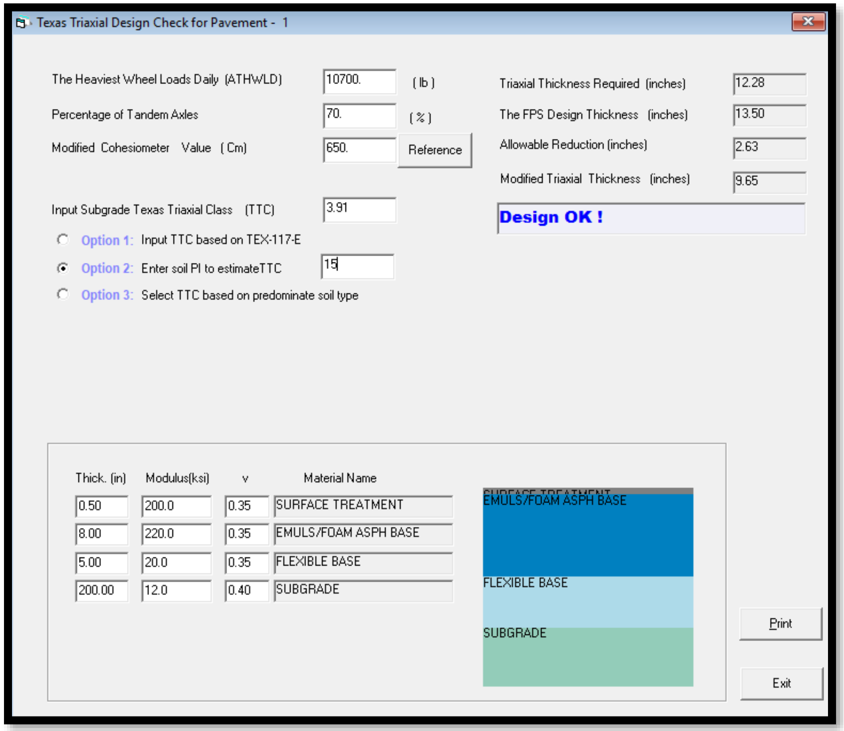
Design Checks

- Design must perform under repetitive traffic loads (FPS design)
- Design must protect subgrade from failure under heavy loads (triaxial check)
- Depending on traffic level and subgrade conditions, triaxial requirements may govern the design

Wide, deep rutting suggests triaxial failure

Example Triaxial Check

- Must define expected heaviest traffic loads
  - Industry/energy sector considerations
- Must define soil characteristics
  - PI, local experience, triaxial class
- For FDR with asphalt binders, cohesiometer value of 650 used



Triaxial requirements may govern the design

Other Considerations, Constraints, and What to Do If No Design Option

- What materials are available? Is additional material required? If so, how much?
  - If more thickness is required, additional material may allow obtaining a passing structural design
  - Must consider both subbase, base, new material and surface layers
  - Depending on traffic level, HMA may be required
- Is segmenting appropriate based on traffic or materials?
  - Segmenting may help with projects where achieving a global passing design is difficult

- Do profile requirements exist?
  - Impacts viable strategies, particularly if thickening the pavement is required to meet the design
  - Sometimes the only option to meet the pavement design is to raise the road or undercut
- Is widening required?
  - If so, recommend scarifying and spreading full width prior to FDR
  - Impacts material balance, profile, requirements for additional material, and proportioning of materials in mixture design
- Do the materials meet the mix design requirements?
  - If no, are other materials available?
- Is the project cost effective?
- Have other alternate strategies been evaluated?

Part III Summary

Design Step	Primary Responsibility	Comment
Determine traffic	TP&P, district, MNT	Realistic traffic estimates required
FPS design	MNT/district	Requires inputs from upfront testing. Must coordinate with lab mix design.
Design checks	MNT/district	Triaxial requirements may govern
Evaluate alternate designs	District/MNT	Is FDR the optimum strategy?
Select proposed typical section	District	Must balance cost, constructability and risk

Pavement design is critical in project development.
Requires inputs from upfront testing.
Requires coordination between district, MNT and lab mix design.

Part IV

Mixture Design

Mixture Design Must…

- Harmonize with pavement design
- Screen out nonviable treatments
- Identify treatment rate(s) and material combination(s) that meet project requirements
- Report information needed for construction

General Steps for Mixture Design

Step	Description	Action
1	Material sampling	Obtain material samples representing anticipated project materials in enough quantity for the anticipated number of mixture designs.
2	Basic materials tests	Determine the moisture content, particle size analysis, PI, classification, and sulfate and organic content.
3	Treatment selection	Select candidate treatments based on goals of treatment, project requirements, material availability, and additive treatment selection guide.
4	Mixture design	Perform mixture design based on goals of modification or stabilization.
5	Reporting	Select and report the lowest additive content meeting project requirements and the associated maximum density and optimum moisture content.

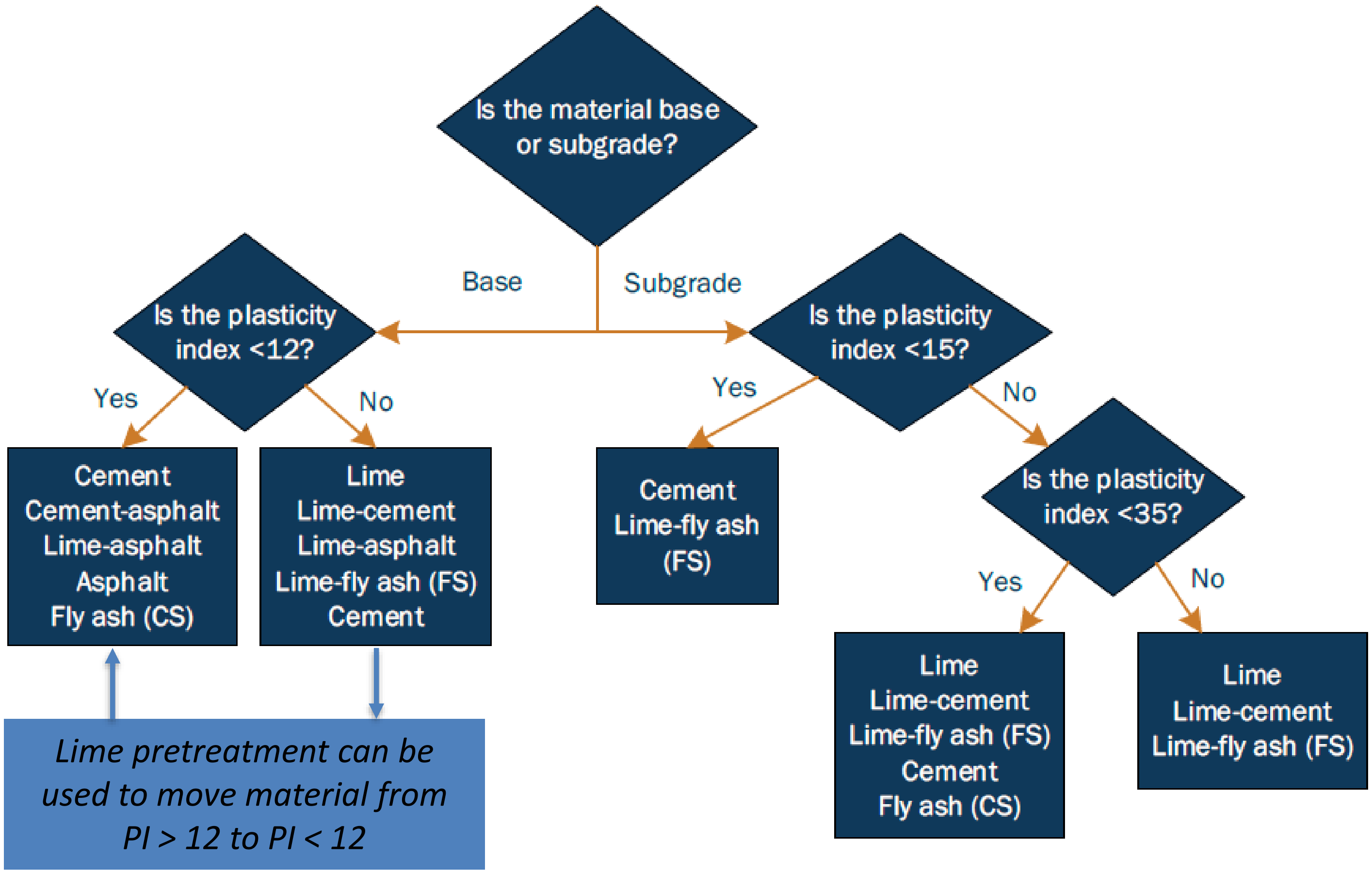
Assistance available — contact MTD

Basic Materials Tests

- Plasticity index
  Tex-104-107-E
- Gradation
  Tex-110-E
- Sulfates or organics
  Tex-145 or Tex-148-E

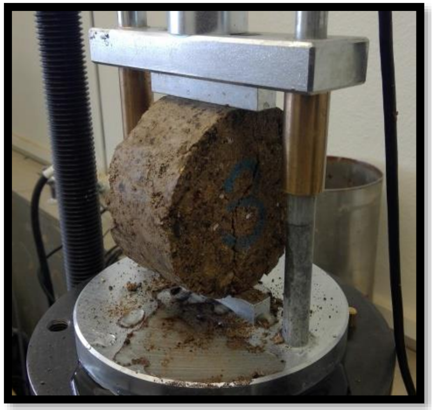
Measuring basic material properties

Treatment Selection



Mix Design Steps

- Cement: Tex-120-E
- Lime: Tex-121-E
- Emulsion: Tex-122-E
- Lime-fly ash: Tex-127-E
- Foamed asphalt:
  Tex-134-E



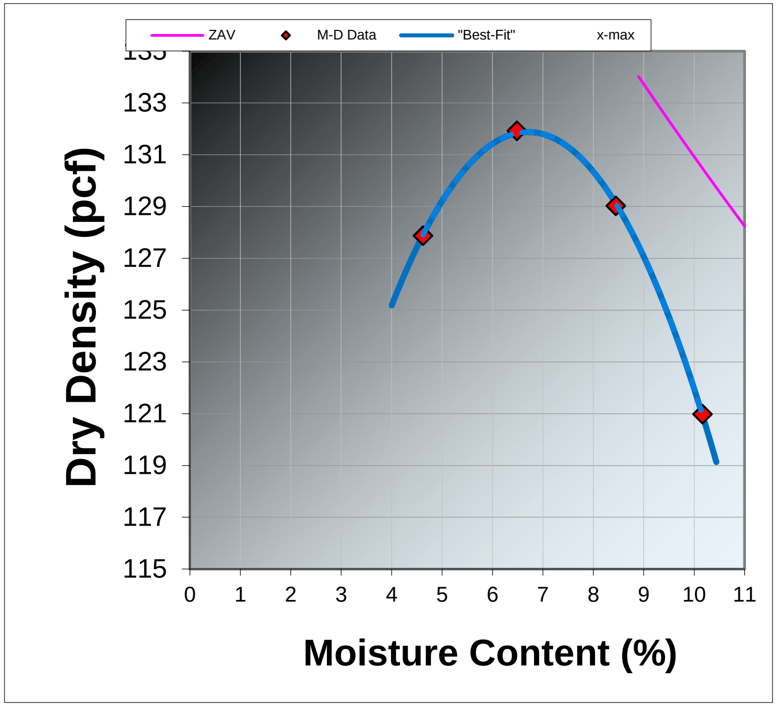
Tex-122-E and 134-E use IDT and UCS

Advantages of Small Sample IDT

- Selecting optimal FDR treatment may include:
  - Multiple stabilizer types
  - Multiple stabilizer levels
  - Different percentages of salvage/new material
- Can easily reach ≥ 8 different designs
- Amount of material required using 6×8 sample size can become burdensome

Example Procedure

- 3-in. new base with 6-in. salvage material
- Tex-113-E
- Both emulsion and foam mixture designs

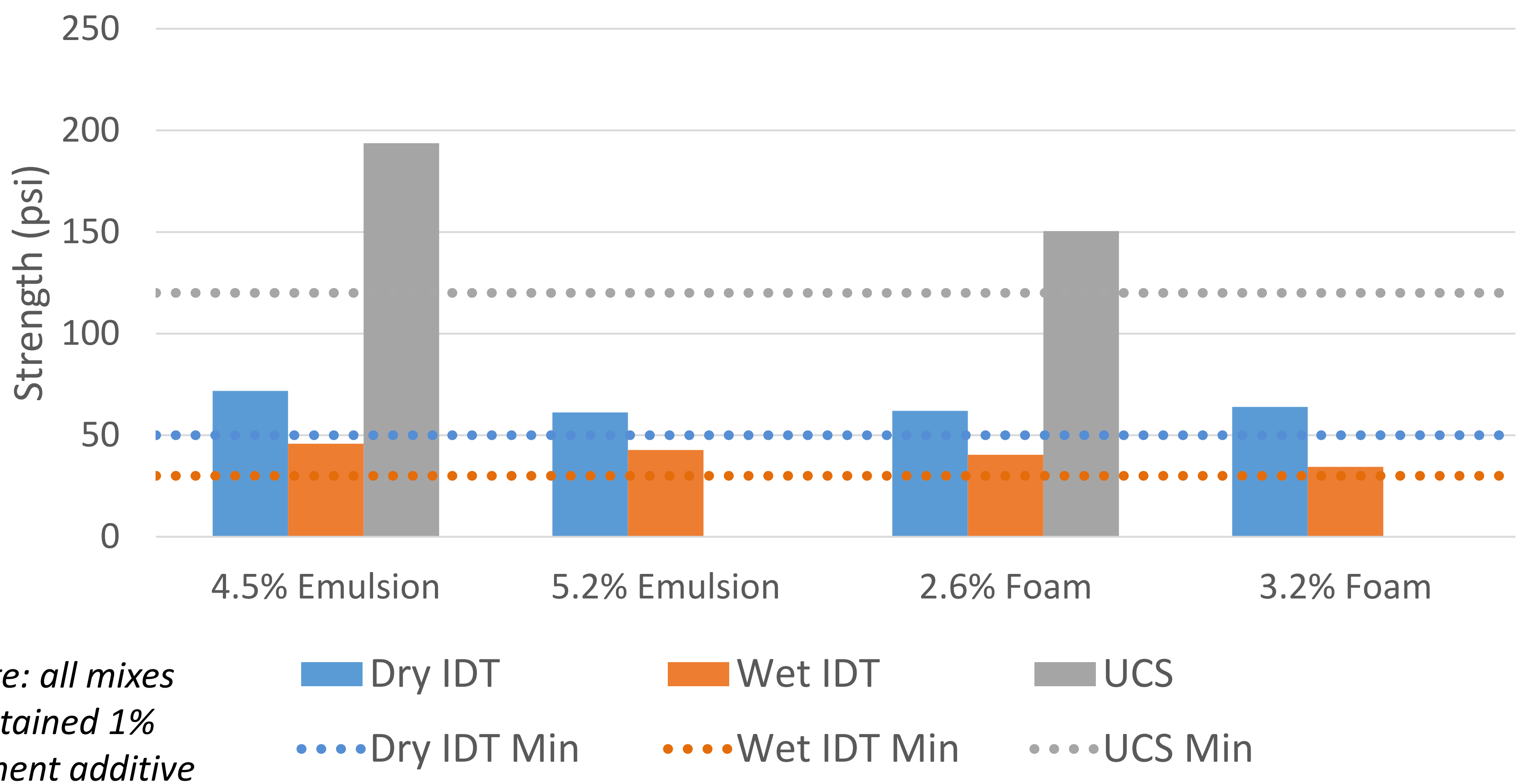


131.9 pcf @ 6.7% moisture

Example Procedure

IDT (unconditioned): 50 psi min.
IDT (moisture conditioned): 30 psi min.
UCS conditioned: 120 psi min.

Example Procedure



Note: all mixes contained 1% cement additive

Special Considerations for Mixture Design

- For emulsion or foamed asphalt – the additive (generally cement) should be limited to 1%
  - Up to 1.5% is allowed
  - Special considerations may exist when lime is used as a pretreatment to lower PI
- For cement – research exists to develop option of mix design based on IDT

Contact MTD for more details on Mix Design Considerations

Example Mix Design Summary

TEXAS DEPARTMENT OF TRANSPORTATION

Mixture Design Summary
Tex-122-E

Refresh Workbook

Tex-122-E - File Version 12-11-20

SAMPLE ID:		SAMPLED DATE:	
TEST NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		GRADE:	
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:		STATION:		DIST. FROM CL:	

Type of Emulsion	gon - CSS-1H (Pleasant	Residue by distillation, (%)	62%

MATERIAL GRADATION: Tex-101-E - Part II

Material	Flexible Base (Stockpile)	RAP (Roadway)	Salvage Base 1	RAP (Roadway)
Description	New Base	Top RAP	L1 Base	Bottom RAP
Sieve	% Retained	% Retained	% Retained	% Retained
1 3/4	0.6%	0.0%	0.0%	0.0%
1 1/4	13.1%	0.0%	5.9%	0.0%
7/8	14.0%	0.3%	14.1%	0.3%
5/8	11.9%	1.5%	12.9%	2.2%
3/8	15.7%	14.4%	14.5%	1.3%
#4	15.2%	34.0%	8.3%	36.3%
#40	20.0%	40.8%	18.0%	47.8%
Pan	9.4%	9.0%	26.3%	12.2%
Total	100.0%	100.0%	100.0%	100.0%

DESIGN SUMMARY: Tex-122-E

Optimum Moisture Content, (%)	5.5%	Flexible Base (Stockpile), (%)	38%
Maximum Dry Density, (pcf)	134.4	RAP (Roadway), (%)	31%
Selected Mixture Design	Mixture 1	Salvage Base 1, (%)	17%
Emulsion Content, (%)	3.6%	RAP (Roadway), (%)	14%
Cement Content, (%)	1.0%	Average IDT (unconditioned), (psi)	110
Lime Content, (%)		Average IDT (conditioned), (psi)	76
	☐ Lock Selected Design	Average UCS (conditioned), (psi)	167

QUANTITY ESTIMATOR

Treatment Depth, (in)	8.0	
Treatment Rate Asphalt	(gal/SY)	3.40
Treatment Rate Cement	(lb/SY)	8.06

Design summary contains key info to construct project

Quantity estimator gal/SY or lb/SY for emulsion or foamed asphalt, and lb/SY for additive

Part IV Summary

<table>
<tr><th>Mix Design Type</th><th>Primary Responsibility</th><th>Comment</th></tr>
<tr><td>Cement, lime or LFA</td><td>District or MTD</td><td>These routine treatments can be developed through local district or area office labs. Current research is exploring use of small samples with these treatments.</td></tr>
<tr><td>Asphalt emulsion</td><td>MTD or select districts</td><td rowspan="2">Require more specialized equipment and expertise. Procedures not yet officially adopted within the department.</td></tr>
<tr><td>Foamed asphalt</td><td>MTD or select districts</td></tr>
</table>

Mix design must harmonize with pavement design.
Requires inputs from upfront testing.
Assistance available — contact MTD.

Part V

Construction Planning and Startup

Construction Planning and Startup

- Quantity estimates
- Order materials
- Hold pre-construction meeting
- Schedule construction
  - Try to avoid cold months – material needs to be at least 50 °F
  - Proper startup
  - Ongoing process control
  - Compaction and finishing

Assistance available — contact MNT

Quantity Estimates

- Require input from mixture design
- Typical rates:
  - Additive (cement): 1%
  - Foam: 2.5%
  - Emulsion: 4%

Area and Depth to Treat	
Select area input format:	
FDR Treatment Depth (in.):	
Total project SY:	

Quantity Estimates

Item	Description	Unit	QTY	Unit Price	Amount
Asphalt*		Gal	0		
Flexible Base (Stockpile)		CY	0		
				Total	0.00

**Asphalt estimate includes an 8% increase from theoretical to account for minimum 6" treatment overlap in adjacent cutter passes.*

A spreadsheet tool available from RTI (Product 0-6880-P13) can help estimate quantities

Ordering Materials

- Suppliers must know requirements:
  - Additive (typically cement): applied topically prior to adding/mixing asphalt
  - Asphalt transports: must have pintle hitch
  - Hot oil for foam
    - Must be prequalified to meet the minimum foaming requirements
    - Must be delivered at temp, typically ~350 °F

Districts should establish required materials in their MMCs

Ordering Materials — Asphalt Requirements

Application	Typical Binder	Requirements
Emulsion	CSS-1H	Meet Item 300 or applicable Special Specification
Foamed asphalt	PG64-22	Half life (min.): 6 seconds Expansion ratio (min.): 8 times

Contact MTD for assistance with testing binders

Hookup Requirements for Pushing/Pulling Transports

- Oil transport must be equipped with pintle hitch at back to be pushed by reclaimer
- Compaction water truck must be equipped with pintle hitch at front to be pulled by reclaimer

Loop at end of tow bars must mate to pintle hitch on transports

Preconstruction Meeting

- Should take place prior to every project
- Helps foster a smooth startup where each party knows what to expect and what area(s) that party is responsible for

Recommended Preconstruction Meeting Agenda

Agenda Item	Description
1	Review all mobilized equipment and outstanding resource needs
2	Safety requirements in the work zone
3	Traffic control plan
4	Anticipated start date, working hours and production rate
5	Review mixture design
6	Review construction sequence, including staff roles and responsibilities
7	Discussion
8	Action items

A pre-construction meeting should take place for every section

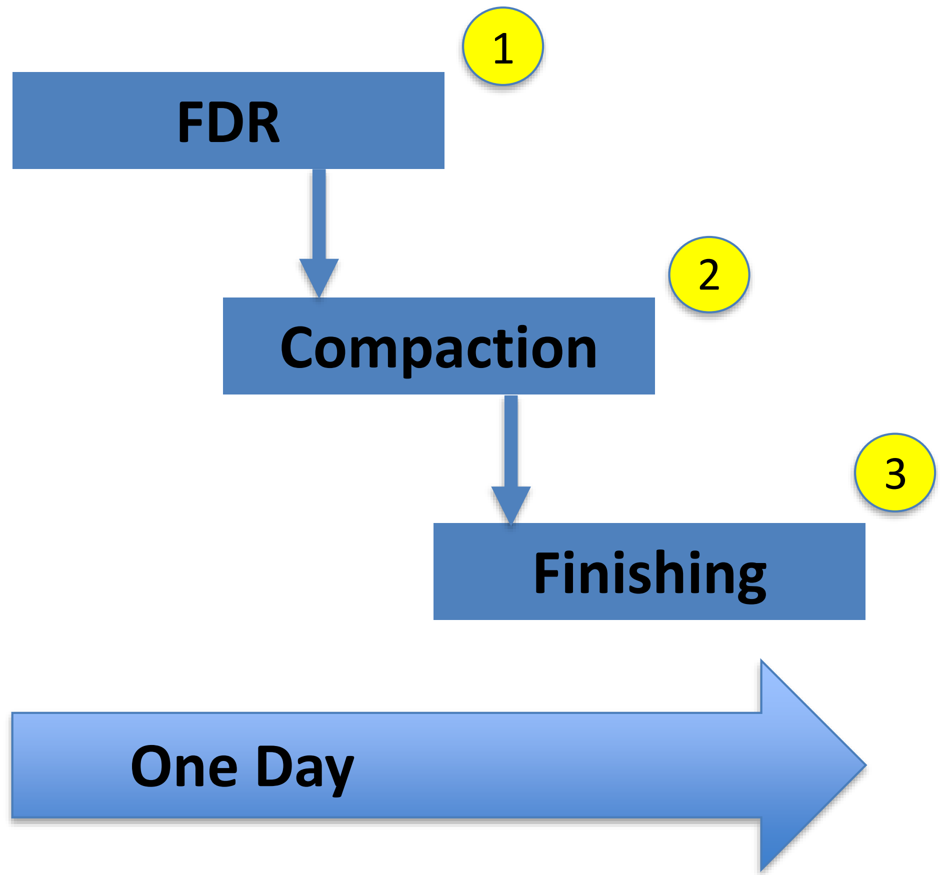
Equipment Checklist

Equipment	Comments	Status
Required Equipment		
Reclaimer with tow bars and hoses		☐
Water truck with pintle hitch, 2500 gal. min.*		☐
Padfoot roller, 20t		☐
Blade		☐
Pneumatic roller, 14t		☐
Flat wheel roller, 10t		☐
2nd water truck for sprinkling*		☐
Distributor with fog emulsion		☐
Other	Insert type of equipment here	☐
Optional Equipment		
2nd padfoot roller		☐
2nd blade		☐
Power broom		☐
Density gauge		☐
Other		☐
Supplies		
1 3/4 and 3/4 in. sieves and scale		☐
PPE for working with oil		☐
Replacement cutting teeth		☐
Lube for daily maintenance		☐
Other	Insert description here	☐

*at least one water truck must have a working pump to fill foam water tank on reclaimer if process uses foamed asphalt

Construction

FDR in progress
Must complete all 3 steps in 1 day

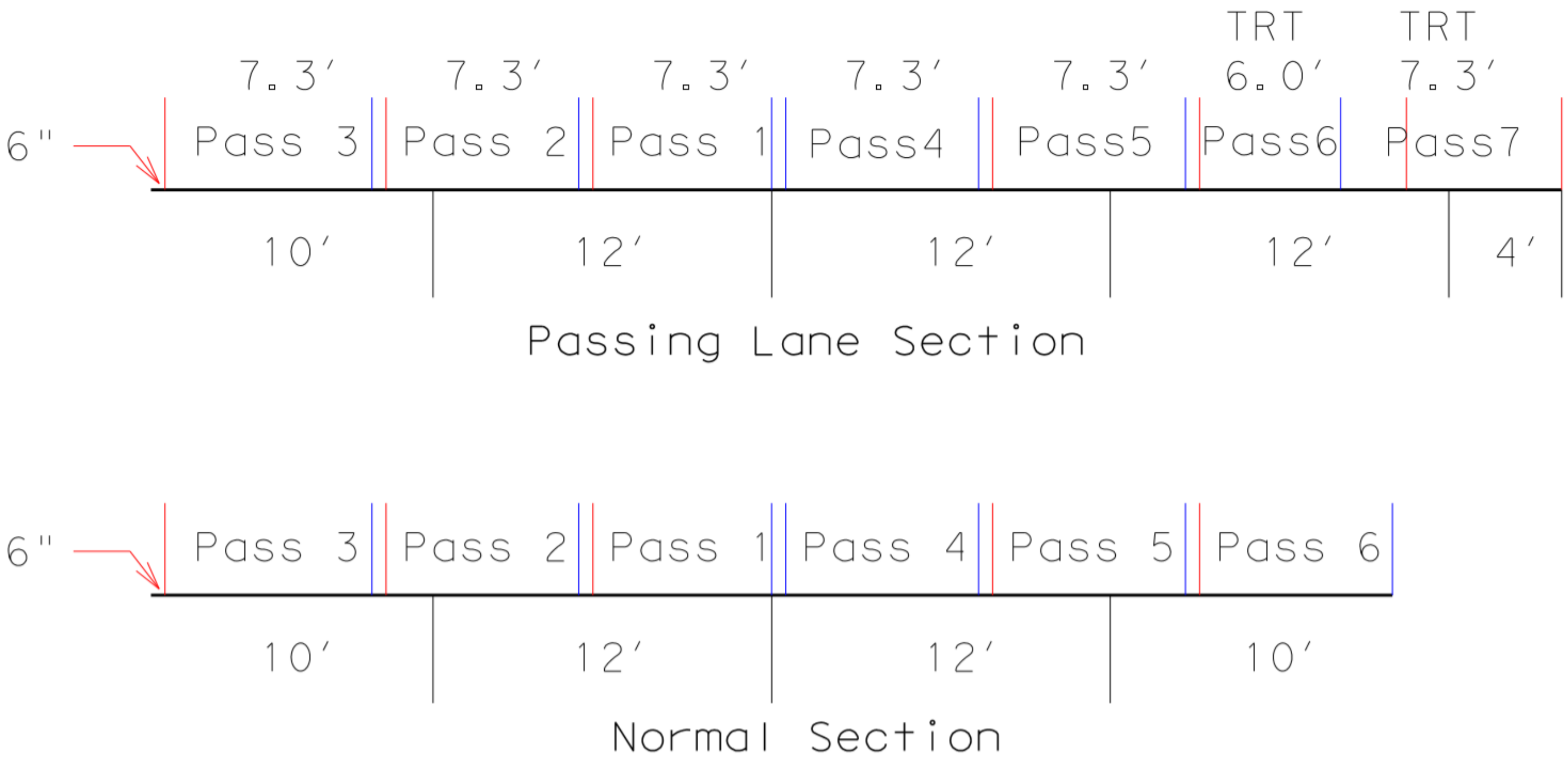


Construction Startup — Cut Plan

- Overlap adjacent passes at least 6 in.
- Recommend squaring off each cut
- Try to avoid overlap or long. joints in wheel paths
- Cut lines for operator
  - Sometimes existing paint stripes work
  - May have to paint cut lines
  - Or use blade to strike off and expose edge of prior cut

Painted cut line for reclaimer to follow

Example Cut Plan

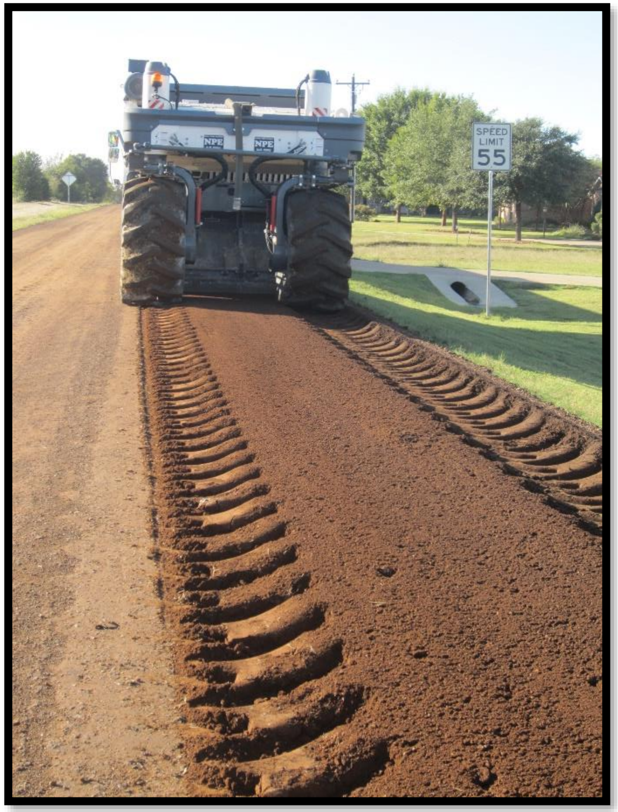


Construction Startup — Pulverization Check

- Must set processing speed
  - Proper pulverization
    - Cutter RPM and gate pressures can also be varied if needed to meet pulverization requirements
  - Generally 20 to 40 fpm
  - Harder materials could be as slow as 10 fpm
- Also set amount of compaction water to add
  - Target 2% below to 0.5% points above optimum after addition of all water and treatments

Pulverization Check

- Must be established at start with varying machine speed
- Does not add any treatments
- Goal: 1 pass operation
  - Additional pass(es) may be required for aerating
  - Pre-pulverization may be useful if high variability is expected



Pulverization check

Pulverization Check

100% passing 1¾-in. sieve.
85% (min.) passing ¾-in. sieve

Existing moisture also checked during pulverization check

Hookup of FDR Train

Push oil transport, pull compaction water transport.

Oil supplier needs to be aware of special delivery temp, pintle hitch and cam-lock connection requirements.

A second (smaller) water truck is needed for filling the foam water tank and sprinkling during finishing operations.

FDR Train

Spreading additive

Pulverization, application of oil and moisture in one pass

Ongoing Process Control during FDR

- Ideally one pass
  - Proper depth
  - Proper gradation
  - Proper moisture content
  - Properly mixed
  - With proper stabilizer rate

Out the back of the recycler is the uncompacted final product

Routine inspection of FDR mix should occur on-site

Compaction

- Should be in 1 lift
- ~20 ton roller for primary compaction
- Set rolling pattern upon startup of FDR treatment
  - Generally 3 to 8 passes
- Must walk out

Compacting FDR mix

Compaction

- Can use multiple rollers during compaction
- Still must walk out and follow established rolling pattern

Using 2 padfoot rollers for compaction

Compaction – Guidelines for Minimum Roller Requirements

Layer Thickness	Minimum Roller Weight (tons)	Roller Type
< 6 in.	12	Vibratory steel wheel
6 – 8 in.	15	Vibratory steel wheel or padfoot
8 – 10 in.	18	Vibratory padfoot
> 10 in.	20	Vibratory padfoot

Source: Wirtgen Cold Recycling Technology

Compaction – Checking uniformity through Depth

- Can test with density gauge at full and then at ~ half of layer thickness
- Can also use DCP penetration rate through depth of FDR layer

Contact MNT for further questions or assistance with determining compaction uniformity

Checking 10” layer thickness with DCP for compaction uniformity

Finishing

- Do not need to excessively work material
- Maintain moisture by sprinkling

Finishing must be completed same day as treatment

Finishing with blade, pneumatic and flat wheel roller

Finishing

- Need to remove tamping marks or ride will suffer
  - Normally in maintenance setting, a seal coat is the final surface

Finishing

Sprinkling to preserve surface moisture during finishing

Light fog at end of each day is best practice (~0.07 gal/SY)

Finished Section

- Foam — 2 hrs. curing
- Emulsion — cure to 2% points below optimum
- In maintenance setting, operational environment may require other approaches

Control of moisture is especially critical if early opening to traffic is required

Finished section after fog

Finished Section – Final Surface

- FDR treatment must have a final surface
- Should apply next course within 14 calendar days of compaction
- Construction staging and traffic levels will influence timeline

Part V Summary

Construction Planning and Startup Step	Primary Responsibility	Comment
Quantity estimates	District	Coordinate with mix and pavement design. Tools exist from RTI and MNT to assist.
Order materials	District	MTD can assist with material requirements.
Hold pre-con meeting	District/MNT	May include suppliers and TCP provider. MNT may help with discussion topics.
Secure required equipment	District/MNT/ FOD	MNT manages set of FDR equipment. FOD assists with mobilization.
Construction startup	District/MNT/ MTD	Establish processing speed, pulverization, compaction water and rolling pattern

Successful construction planning and startup require coordination of district, MNT, FOD and MTD

Wrap-Up

Overall Summary and Contacts

Overall Summary

- FDR can rapidly renew pavement
- Proper project selection is key
- Requires resources from district, MNT, FOD and MTD

Before

After

Overall Summary – Equipment Resources Available to Districts

- 2 – pavement reclaimers
- 2 – padfoot rollers
- 2 – pneumatic rollers

Overall Summary

FDR Development Step	Key Resources	Comment
Upfront testing	District, MNT, MTD	Historical info, nondestructive tests and sampling
Pavement design	District, MNT, TP&P	Traffic inputs; FPS. Must coordinate with upfront testing and mix design.
Lab mix design	District or MTD	Must coordinate with upfront testing and mix design
Construction planning and startup	District, MNT, FOD, MTD	Secure required resources. Set production processes to meet process control requirements.

Successful development of FDR projects using in-house resources requires coordination of district, MNT, FOD, MTD and TP&P

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