Advanced Tools for Comprehensive Evaluation of Pavement surface and subsurface conditions

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Overview of Presentation

1. Background to TTI and TxDOT
2. Types of Non-Destructive Testing tools
3. Demonstration of PaveCheck Software
4. Use of NDT in FDR Projects
5. Use of NDT in Pavement Forensic Investigations
6. Use of NDT in Corridor Studies
7. Future Directions

CENTER FOR INFRASTRUCTURE RENEWAL (CIR)

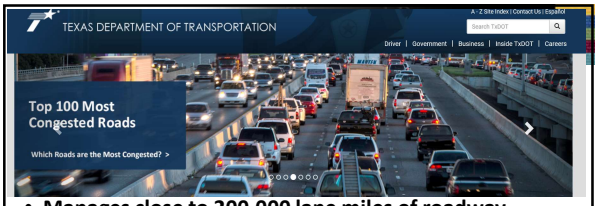
1. Background to TTI and TxDOT

Texas Transportation Institute

1) **Part of the College of Engineering at Texas A&M University**
2) **60+ Years of research on Transportation Systems**
3) **Largest University-Affiliated Transportation Research Organizations in the USA**
4) **Major Source of Educated Transportation Professionals**
5) **Partners Extensively with TxDOT, other Public & Private Organizations**
6) **New Lab 2018 new TTI Building 2019**

Flexible Pavement Program

- Research Studies
  - Balanced Mix Design for HMA
  - FDR for Energy Sector,
  - Development and implementation of new Technologies
- Interagency Agreements
  - Agency support with Forensics, Pavement Rehab
- Training Workshops
  - Seal Coats/Thin Overlays
  - FDR
  - Rubblization
  - Pavement Design
  - Nondestructive Testing
  - Intro to Paving Materials



- **Manages close to 200,000 lane miles of roadway**
- **Does not include County or City Roads**
- **2018 TxDOT Budget $13 B**
  - **$9 B State Roads $4 B Toll Road Construction**
- **For State Roads: Designs mostly done in house**
- **Governor and Citizens want more funding for roads**
- **1000 people a day coming to Texas**
  - **Massive construction/widening projects underway**
  - **Energy Sector Boom (still booming)**

TxDOT Design Work

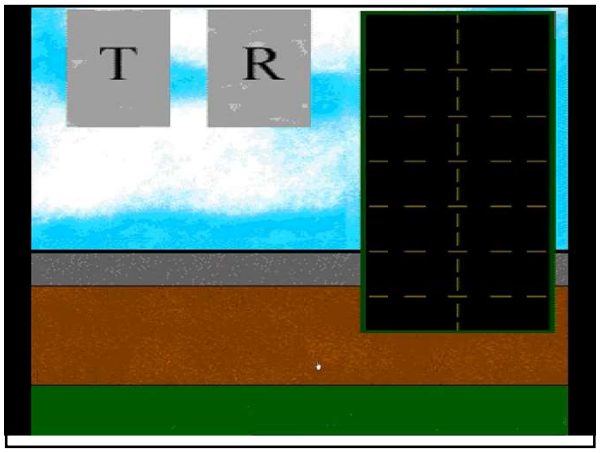
- 25 Districts; all manage roughly 6000 to 8000 lane miles
- Each District has 3 to 4 Area Offices managed by an Area Engineer who comes up with proposed rehabilitation strategies and pavement designs
- Most work: rehabilitating – widening old roadways
- Area Offices supported by
  - District Pavement Engineer
  - Austin Divisions
  - University Researchers
  - Private Consultants (2017 on)

2. NDT Evaluation Tools

Used extensively for selecting rehab options when pavement performance is poor or premature failures exists

NDT Air-Coupled GPR

- **Data Collection and Processing software developed by TTI**
- **Training schools taught by TTI**
- **TxDOT has 5 available units**
- **Data collected and processed by TxDOT**
- **Data collected at highway speed (60 - 70 mph)**
- **Effective depth of penetration 20 ins**
- **Measures layer thickness, locates subsurface defects and section breaks**



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Successful GPR Applications

- Thickness of Pavement Layers
- Defects in Base (Wet areas)
- Defects in Hot Mix layers (stripping, trapped moisture)
- Identifying areas of segregation and poor joint density
- Deterioration in asphalt covered bridge decks
- Water filled voids under PCC
- Pavement Rehabilitation studies (identifying changes in structure)

Does not eliminate but permits smarter coring

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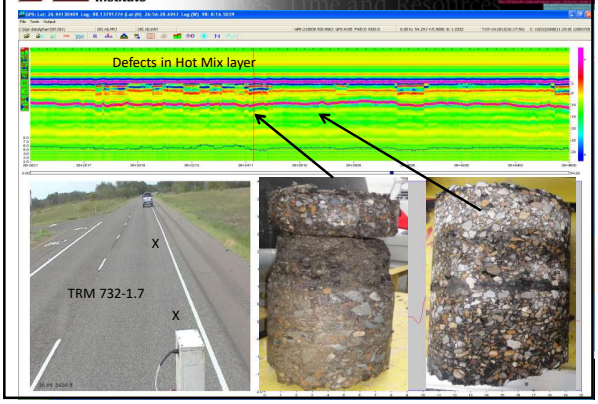

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Importance of site investigation

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Importance of site investigation

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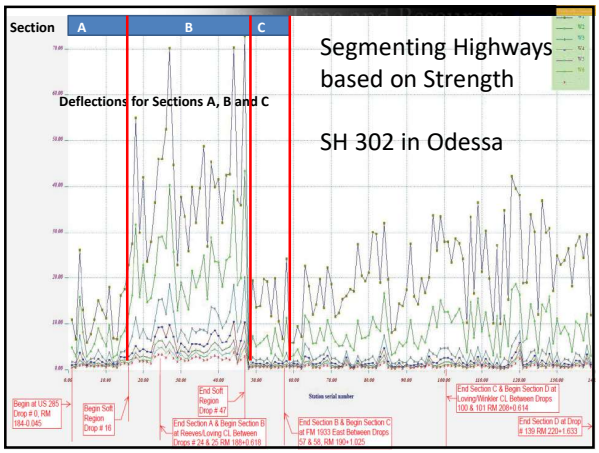
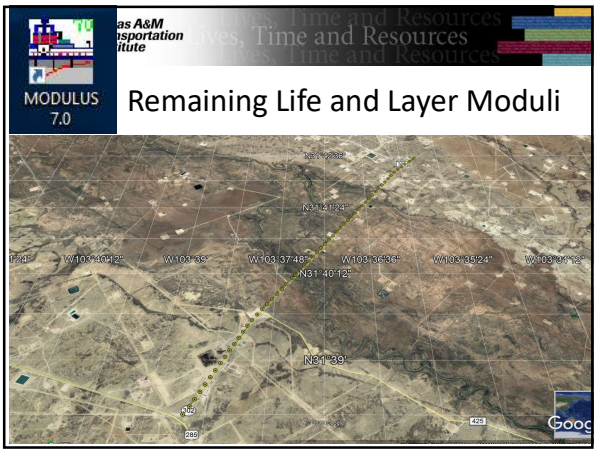
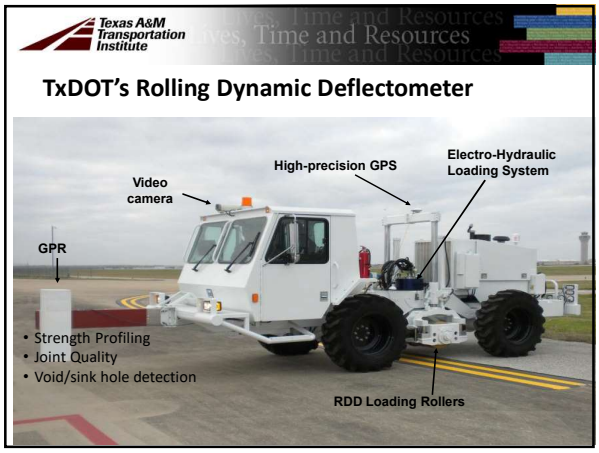
Falling Weight Deflectometer Testing


Section
A
B
C
Deflections for Sections A, B and C
Segmenting Highways based on Strength
SH 302 in Odessa


MODULUS 7.0
Remaining Life and Layer Moduli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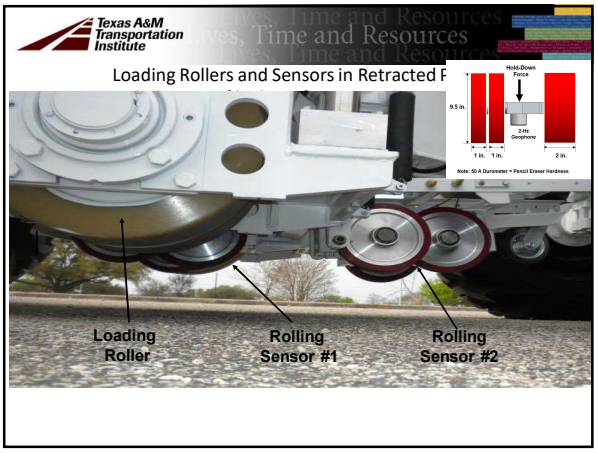
TxDOT's Rolling Dynamic Deflectometer
Video camera
High-precision GPS
Electro-Hydraulic Loading System
GPR
• Strength Profiling
• Joint Quality
• Void/sink hole detection
RDD Loading Rollers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Loading Rollers and Sensors in Retracted P
Loading Roller
Rolling Sensor #1
Rolling Sensor #2


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Rolling Deflectometer in Action
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Very poor support
Very poor joints

4. Use of NDT Tools in FDR projects

Challenges and Opportunities for FDR in Texas

- Opportunities No shortage of candidates
  - Inadequate structure for loads
  - Inadequate width

Challenges
- Variable pavement structure
- Construction on top of expansive clays
- Often poor existing base materials
- Early opening requirements in Energy Sector
- Need to accelerate Lab designs
- Need updated Specs and Design recommendations

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Critical Steps in the FDR Process

1. *Assemble Background information*
   - ✓ Coring logs
   - ✓ Maintenance
   - ✓ Typical section
2. *Non-destructive testing*
   - ✓ Ground Penetrating Radar (GPR)
   - ✓ Falling Weight Deflectometer (FWD)
   - ✓ Determine thickness & strength variability
   - ✓ Determine sampling locations
3. *Verify Pavement Structure & Sampling*
   - ✓ Auger or milling machine for sampling.
   - ✓ Drill logs for project

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4. *Laboratory Mixture Design*
   - ✓ Plasticity Index
   - ✓ Moisture-Density Curve
   - ✓ Binder tests (foaming)
   - ✓ Asphalt %, additive %, add rock % and foaming water %
5. *Pavement Thickness Design*
6. *Construction Quality Control*
   - ✓ *Depth of pulverization*
   - ✓ *Gradation*
   - ✓ *Moisture content*
   - ✓ *Emulsion content*
   - ✓ *Foaming asphalt properties*
7. *Construction Quality Assurance – Density*
8. *Performance Evaluation – FWD and Visual*

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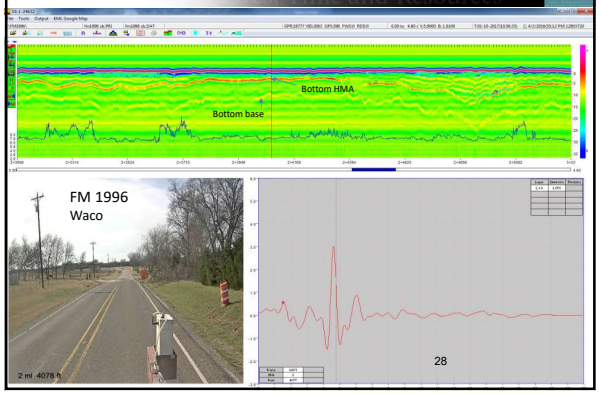

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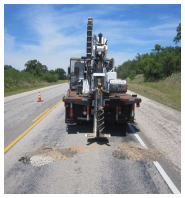
Step 3 in the FDR Process

Sampling Equipment
- Use GPR/visual information to determine sampling locations.



Auger

Milling Attachment

Gradall

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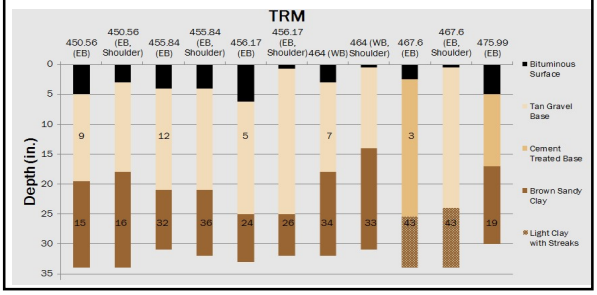
Critical Steps in the FDR Process

Coring Log



Why Upfront Testing

TxDOT 1st foamed asphalt project (2000) < 1 year old

SEVERE RUTTING, ALLIGATOR & LONGITUDINAL CRACKING | CENTER/BETWEEN WHEELPATHS | OUTSIDE WHEELPATH

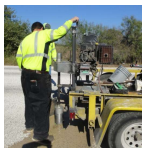
Recycled 10 inches deep - Problem: locally only 7 inches of pavement over black clay
Next Foamed Asphalt job 2013

So How are we doing

- 2015 – 2018 total of 12 projects constructed using these guidelines
- Follow performance evaluations on-going
  - Visual
  - FWD survey
  - Coring (some)

Post Construction Evaluation on FM 541 San Antonio

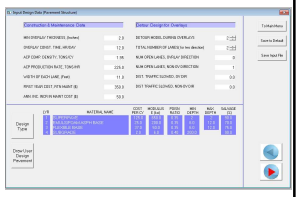
- 1% Cement + 2.4% Foamed asphalt PG 64-22
- 4 ins add Rock + 6 ins existing
- 10 inch deep in one pass
- Open to Traffic in two hours
- 3 mile project
- 4 times faster than current undercutting design
- Backcalculated Design Modulus 303 ksi



Structural Design with FPS 21

Pavement Design Thickness

- Use Texas Flexible Pavement Design System (FPS 21) software to determine minimum FDR layer thickness.
- Required backcalculated modulus for all layers (MODULUS 7)



MODULUS 7 FWD Results (ETB IH 10)

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 6.1)

District:
County
Highway/Road:

Layer	Thickness (in)	Modulus Range (psi) Minimum	Maximum	Poisson Ratio Values
Pavement:	6.50	663,400	663,400	E1: v = 0.35
Base:	10.00	90,000	400,000	E2: v = 0.35
Subbase:	0.00			E3: v = 0.00
Subgrade:	181.22 (by DB)	15,000		E4: v = 0.40

Station	Load (lbs)	Measured Deflection (mils): R1	R2	R3	R4	R5	R6	R7	SURF(E1)	Calculated Moduli values (ksi): BASE(E2)	SUBB(E3)	SUBG(E4)	Absolute Dpth to ERP/Dens	Bedrock
0.000	9,957	10.43	8.02	5.63	3.88	2.68	1.89	1.46	663.4	387.8	0.0	15.2	1.74	208.5
101.000	9,964	10.86	8.41	6.01	4.09	2.76	1.94	1.48	663.4	378.6	0.0	14.6	3.15	220.1
201.000	9,973	12.46	10.01	7.00	4.82	3.32	2.13	1.81	663.4	322.9	0.0	12.3	4.11	140.2
301.000	9,980	13.86	11.39	8.49	6.08	4.40	3.21	2.49	663.4	304.2	0.0	10.1	4.31	278.7 *
408.000	9,009	11.40	8.73	6.22	4.49	3.25	2.51	1.98	663.4	400.0	0.0	13.3	2.54	300.0 *
510.000	9,104	9.70	7.08	4.68	2.92	1.94	1.37	1.10	663.4	400.0	0.0	20.4	4.01	193.2
600.000	8,949	9.43	7.35	5.23	3.69	2.44	1.70	1.33	663.4	400.0	0.0	16.9	2.62	193.0 *
712.000	9,068	10.94	8.81	6.01	4.00	2.61	1.79	1.36	663.4	394.4	0.0	15.0	5.04	174.4
804.000	9,088	12.49	8.98	6.08	4.08	2.74	1.92	1.41	663.4	257.0	0.0	14.7	1.91	203.6
906.000	8,901	12.81	10.00	6.26	3.91	2.54	1.72	1.32	663.4	181.2	0.0	14.8	5.96	173.1
1004.000	9,086	12.37	9.48	6.30	4.20	2.62	2.02	1.64	663.4	244.4	0.0	14.1	2.27	215.3
1101.000	8,925	19.24	13.92	8.33	5.24	3.51	2.53	2.00	663.4	125.4	0.0	10.9	3.53	226.9
1205.000	8,862	12.43	9.39	6.50	4.53	2.90	2.09	1.67	663.4	278.6	0.0	13.3	2.02	212.8
1300.000	8,814	14.47	11.41	7.70	5.04	3.29	2.30	1.91	663.4	216.2	0.0	11.3	4.97	192.2
1403.000	8,786	12.86	9.84	6.38	4.22	2.50	1.58	1.64	663.4	238.9	0.0	13.6	3.21	198.2
1508.000	8,866	12.73	8.60	5.29	3.16	1.98	1.39	1.13	663.4	171.3	0.0	19.4	6.60	140.7
Mean:		12.52	9.42	6.38	4.25	2.87	2.03	1.61	663.4	283.7	0.0	14.3	3.69	191.7
Std. Dev:		2.34	1.59	1.07	0.78	0.60	0.46	0.35	0.0	84.8	0.0	2.7	1.44	40.6
Var Coeff(%):		18.69	16.86	16.76	18.32	20.81	22.40	21.79	0.0	29.9	0.0	19.7	38.96	19.5

Base modulus of 200 ksi assumed for design
Base Modulus computed 283 ksi (two weeks after construction)
Design Base Modulus value 250 ksi (removing outliers)

Conclusions and Recomendations

- Full design needed for each project
- Do not go to construction without a passing lab design
- No failures found with approach presented
- Design modulus for future asphalt based FDR projects 220 ksi
- Monitoring continuing

5. Use of NDT Tools in Forensics Studies

Objectives of Forensic Studies

- What is the cause of the problem
- What should the TxDOT District do now
- How can the problem be avoided in the future
  - "More research is needed"
  - New Specs
  - New test procedures
  - New Equipment

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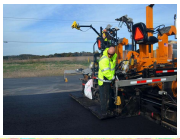
Forensics Studies and their Products

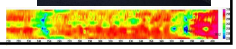
Sulfate Heave

Spectrophotometer
Tx Method 145E

Thermal Segregation

Pave-IR system





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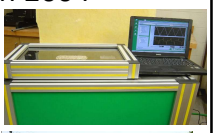
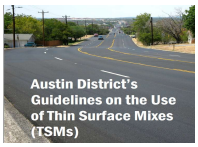
Forensics Studies and their Products

Balanced Mix Design 2004

Premature Cracking



Balanced Mix Design
Scullion/Zhou 2004



IH 10 2002
Tony Yrigoyen – Richard Williammee
Charles Gaskin – Dale Rand

Balanced Mixes CAM 2008
TOM 2009 and SMA 2014

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Recent Forensics Studies

Case 1 Differential Widening problems
Case 2 Drainage not pavement Problems
Case 3 Damage from Truck Overloads
Case 4 Early Cracking of New Concrete

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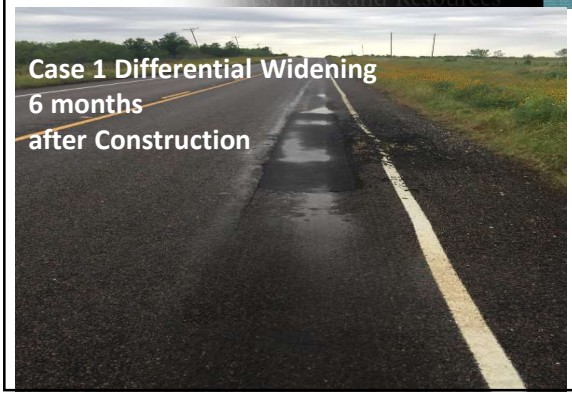

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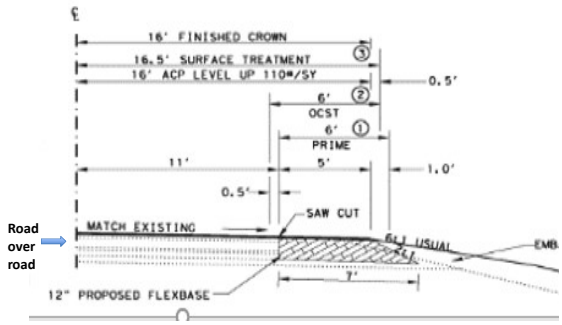

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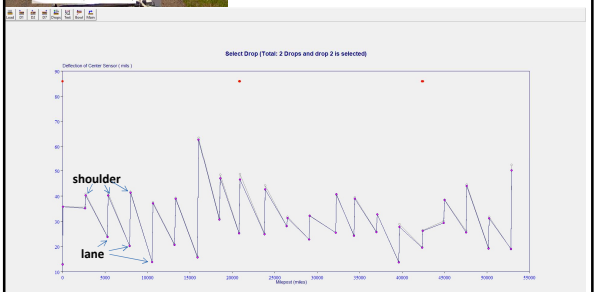
FWD Deflections
Much higher deflection in shoulder



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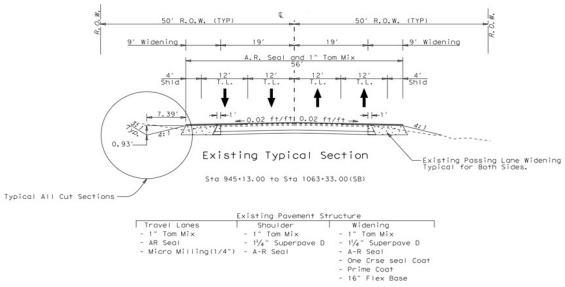
Typical Section – 9ft Widening



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Proposed Design: 9 ft Widening on Existing Pavement

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Representative Distresses –Widened Section

Long. Crack in surface mix at lane joint. Cracking and rutting over original pvmt. Widened OWP good condition.

Cement Treatment of failed shoulder did not work

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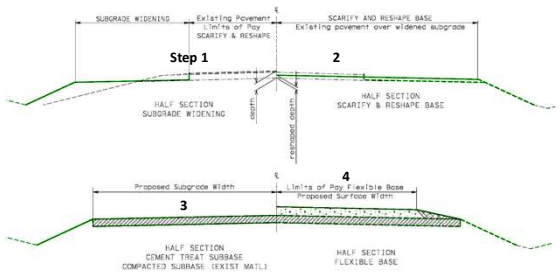
Recommended Widening Typical Section



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Case Study 2

Frequent Repairs – **what is wrong with pavement**

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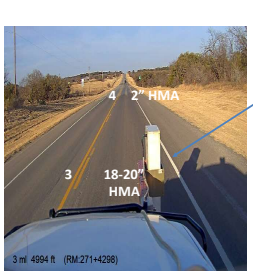
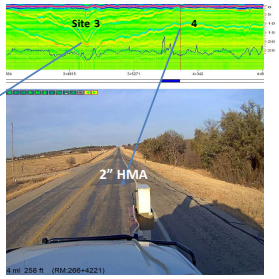
GPR Data





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Site 3

Site 4

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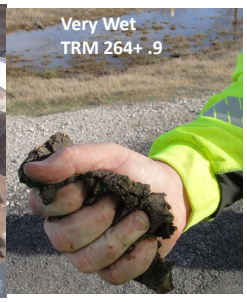
Nasty clay found at all sites



Poor Drainage at all thick locations

Conclusion

Not a pavement layer problem

It is a drainage problem

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Conclusions

- **TxDOT has a very successful forensics program**
- **This program is a critical part of the research cycle**
- **Implementation includes new tools, test procedures and specifications**
- **We get better by learning from our problems not burying them**

Slide 50

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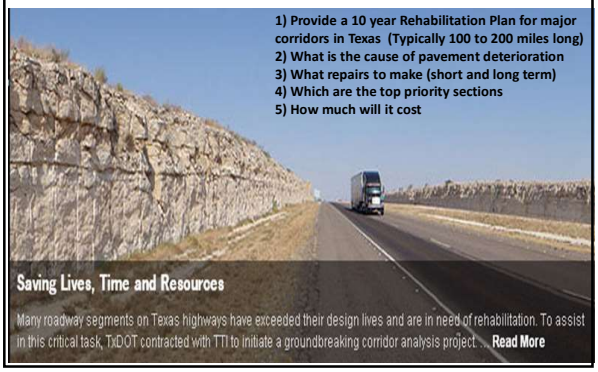
6. Use of NDT in Corridor Studies



Steps in a Typical Corridor Analysis

- Conduct a full GPR survey of each direction of highway
- Meet with DOT personnel to;
  - Define breaks, identify problem sections or upcoming projects
  - Provide traffic estimates for each section
  - Identify their priorities and treatment preferences
- Plan and Execute an FWD and DCP test program
- Plan and Execute a field sampling program including coring to validate defects and auguring (if needed)
- Conduct laboratory testing where required (FDR, Overlay tests, etc.)
- Analyze all of the data collected
- Run Pavement Design options
- Report and Presentation of Findings

Corridor Analysis of IH 20 in the Odessa District

BY
Tom Scullion
Texas Transportation Institute

STUDY SUPERVISORS
Magdy Mikhail
TxDOT Construction Division
K.C. Evans
TxDOT Odessa District

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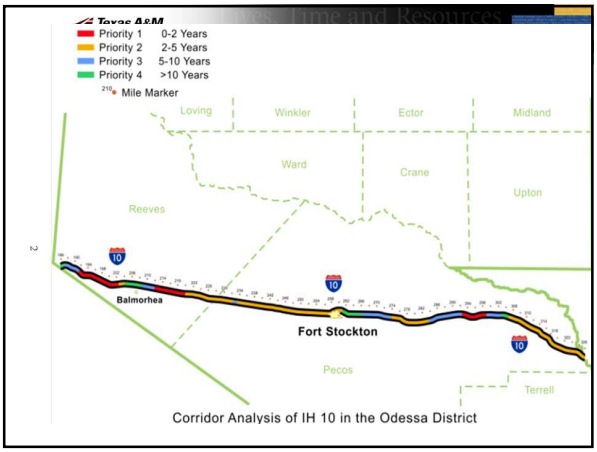


Corridor Analysis of IH 10 in the Odessa District

IH 20	County: Reeves	TRM 19.7 - 25
Pavement Structure: 1996 Base: 21 in Flex Total HMA: 6 - 7 in		Last Treatment: 1996 Type: 4.5 inches of Type B 1.5 CMHB - C

Current Condition:

Distress: Block Cracking with some localized alligator, lots of crack seal
2009 PMIS: Condition Scores from 31 to 76

Cause of Problem:
Severe stripping of the Type B base layer in both lanes both directions and other sections of IH 20 also have severe stripping. An evaluation should be made of the mixes used to identify the cause of this severe deterioration. It is suspected that the problems are both mix and construction related. The local materials we thought to be not stripping susceptible but that does not seem to be the case. Long life pavement concepts involve placing base mixes which do not deteriorate so only surface renewal is required. This is not happening on several sections of IH 20, where complete replacement is now required after 15 years.
Flexible base layer in good condition; from the FWD modulus 100 + Ksi
Subgrade strong 20+ ksi

Recommended Rehabilitation Approach:
Complete replacement of all HMA
Funds should be included in the contract for reworking any suspect areas of base (very few anticipated, less than 5%)
FPS 19 indicate that 6 inches of new HMA would be required for a 20 year design life
A fog seal is planned for ASAP to help hold this section together.

Urgency: High Priority 0 – 2 years
Cost Estimate: $ 6 million

0 – 2 year project

Bad news

IH 20	County: Midland County	TRM 122 - 136
Pavement Structure: 2002 Base: 16 in Flex base Total HMA: 10 in		Last Treatment: 2002 Type: Hot Rubber underseal CR PMS

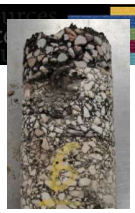
Current Condition:

Distress: Longitudinal cracking, rough ride, failures mostly outside lane outside wheel path
2009 PMIS: Range from 45 to 95

Cause of Problem:
From coring and GPR most of the damage is restricted to top 4 inches of HMA; below that the HMA looks solid. However transverse cracks initiating in lowest layer of HMA have reflected and are seen in both lanes. These cracks are source of problem letting moisture into susceptible layers.

Recommended Rehabilitation Approach:
The FWD indicated that the base layer in both directions is very good.
This is the most heavily traffic section in the District with 29 million ESAL's
Flexible pavement Option: (Time to First Over 15 years)
In outside lane only mill 4 inches place a layer to minimize reflection cracks. This could be a 1 inch crack attenuating layer (SS 3165) or a crack retarding fabric layer, 2 inches of new HMA plus PFC. Mill 2 inches inside lane (CAM + PFC)
Rigid Option If 30 year design required consider, milling 5 inches then full depth CRCP – check with Brownwood for their recent experience with concrete on IH 20

Urgency: High Priority 0 – 2 years
Cost Estimate: High $$(long section all in poor condition both directions)



0 – 2 year project

Good News

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Questions?

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