Accelerated Construction

TxDOT Research 0-6985
Perform Feasibility Study on Use of Innovative Tools and Techniques to Accelerate Pavement Construction

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2020 TxDOT Shortcourse
Definition of Accelerated Construction
(TxDOT, Accelerated construction Guidelines – December 2017)

...Accelerated construction entails all the aspects of getting a project built rapidly including project selection, planning, contracting, **design**, **traffic control**, **construction methods**, publicity, and contingencies.

Outline

- Project Construction Time
- Pavement Evaluation
- Traffic Control
What’s the first thing you think of when you are asked to Accelerate Construction?

Change the Pavement Design
Add milestones
Time

• How Do We Accelerate?
• First we have to understand time
  • Public’s Perception of Project Time
  • Project Time
    • Remove Days don’t work
      • Weekends
      • Holidays
      • Rain/too wet days
### Time - Example based on Tyler Texas Historical Weather

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Perception – 1 year to work but
Reality - only 50% of year is actual working days
Accelerated construction is directed toward minimizing construction zone impacts to the driving public.

How do we design for this?
Pavement Design

- Pavement Design is more than just running software for layer thicknesses
  - Evaluate the existing conditions – Forensic Review
- Develop strategies
  - Forensic Review
  - Time constraints
  - Construction process including traffic control
Why not just remove the old road and build new?

Examples:
Rubblization 7040 sy/day
FDR w/ foamed Asphalt 5280 sy/day
Removal 2000 sy/day
Existing Pavement Evaluation (Forensics)

- Pavement testing equipment and resources.
  - Structural
    - Stiffness
      - FWD
      - TPAD
      - DCP
    - Layer Thickness and Condition
      - GPR
  - Functional Properties
    - LiDAR
    - Profiler
  - Subgrade & deeper
    - ERT
    - Web Soil Survey
Ground Penetrating Radar (General)

- Radar systems to characterize pavement layer quality, thicknesses, and subsurface anomalies.
Ground Penetrating Radar (General)

- Method
  - Transmits pulses of radar energy.
  - Pulse is reflected at significant layer interfaces.
  - System captures reflected waves (voltage vs time).

- Dielectric ($\varepsilon$) and distance ($d$) calculation:

$$
\varepsilon_1 = \frac{1+A_1/A_m}{1-A_1/A_m}^2
$$

$$
d_1 = \frac{c*\Delta t_1}{2\sqrt{\varepsilon_1}}
$$
Ground Penetrating Radar (General)

- Air- and ground-coupled systems.
- Antenna frequency vs. penetration.

High Frequency
2GHz+ 1 GHz
1-4 inches 20 inches

Low Frequency
200 MHz
Up to 30 ft
Ground Penetrating Radar (General)

- Data Analysis
  - PaveCheck (TTI) or vendor software.
- Identify
  - Layer thickness
  - Subsurface distress
  - Structure discontinuities
  - Moisture damage
  - Layer density
  - Compaction uniformity
GPR Systems

• Benefits for Accelerated Construction
  • Efficient forensic investigations.
  • Assess alternative M&R strategies.
  • Timely decision making.

• Limitations and Availability
  • Technical expertise required.
    • Light weight or slag aggregate can look like false problem areas.
  • Coring is not eliminated, “Core strategically” (need to validate analysis).

• Air-Coupled 1 GHz
  • Integrated HD video, GPS.
  • Highway speed data collection.
  • 20-inch penetration depth.
  • Data analysis with PaveCheck.
  • TxDOT owns 5 antennas
Mobile LiDAR System

• Laser-based imaging system (Mobile Total Station)
• Provides a right-of-way geometric evaluation to predict surface drainage behavior.
• Freeway speed data collection.
• Method
  • Scanning array of laser pulses.
  • Returning pulse provides reflectivity of surface and distance in relation to the angle.
  • Correction with inertial and accelerometer data.
• Equipment
  • SICK Laser Scanner
  • Cameras,
  • GPS,
  • Inertial measurement unit,
  • 3D accelerometer.
• Constructed by Roadscanners (Finland)
Mobile LiDAR System

- Measures
  - Rutting
  - Cross-slope
- Data analysis programs under development
- Benefits for Accelerated Construction
  - Forensic evaluation for drainage problems.
  - Information for new construction.
  - More suited for asset management.
- Limitations and Availability
  - Complexity of data analysis.
  - TxDOT owns 1 system.

- Ditch depths and grade
- Drainage basins

Rut Depth (Gurganus 2018)
Falling Weight Deflectometer

• Load-deflection response testing system.
• Used to characterize pavement layer stiffness.
• Static data collection (traffic control required).
• Method
  • Heavy falling weight creates deflection basin (Simulates a heavy moving wheel load)
  • Geophones on surface record deflections.
  • Layer stiffnesses are back-calculated using a linear elastic model.
• Data Analysis
  • MODULUS® program by TTI.
• Identify layer stiffness and uniformity.
• Benefits for Accelerated Construction
  • Efficient forensic investigations.
  • Assess alternative M&R strategies.
  • Timely decision making.
  • Useful for project and network level analysis.
• Limitations and Availability
  • Not suitable for layers <3 inches thick.
  • Traffic control required.
  • TxDOT owns 15 FWD’s.
Dynamic Cone Penetrometer (DCP)

- Penetration depth per blow
- In-situ strength
- Applications
  - forensic investigations,
  - checking compaction uniformity and
  - verifying layer moduli.
- Benefits for Accelerated Construction
  - Check Uniformity of layer compaction
  - Estimate layer moduli
- Limitations and Availability
  - Cost effective tool that is commercially available for purchase
  - Several TxDOT Districts own DCP’s, contact district laboratory
Total Pavement Acceptance Device (TPAD)

- Rolling dynamic deflectometer for continuous deflection profiling.
- Slow driving speed. (Traffic control needed).
- Method
  - Heavy vibrating wheel creates continuous deflection basin, measured by 2 rolling sensors.
  - Layer stiffness back-calculated similar to FWD.
  - Integrated GPR, GPS, and HD video.
- Data Analysis
  - Custom program developed by TTI.
  - Note outlier deflections or back calculate moduli.
- Benefits for Accelerated Construction
  - Efficient forensic investigations.
  - Assess alternative M&R strategies.
  - Timely decision making.
  - Test of load transfer in jointed concrete.
- Limitations and Availability
  - Not suitable for layers <3 inches thick.
  - Traffic control required.
  - TxDOT owns 1 TPAD.
Inertial Profiler

• Laser and inertial roughness (IRI) profiler to quantify ride quality.
• Data collection at high speeds.
• Method
  • Tex-1001-S.
  • The profile in each wheel path is collected with spot lasers and corrected with inertial data.
• Profiles can be used to calculate the international roughness index (IRI).
• Data Analysis
  • TxDOT Ride Quality software.
  • Various simulations with profile data:
    • Vehicle dynamics
    • Profilograph
    • Power spectral analysis
• Benefits for Accelerated Construction
  • Identify location and severity of rough spots to then select an appropriate treatment for long term functionality.
  • Timely decision making.
• Limitations and Availability
  • Not suitable for stop-and-go environments.
  • Annual certification for QC/QA and network inventory.
  • TxDOT owns 5 profilers.
USDA Web Soil Survey

• Web Soil Survey (WSS) provides soil data and information produced by the National Cooperative Soil Survey.
  • https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

• Benefits for Accelerated Construction
  • Identify potential problem areas as well as good areas.
  • timely decisions

• Limitations and Availability
  • Free access web site supported by the United States Department of Agriculture
  • Limitations in the data is described when using the web site.
Electrical Resistivity Tomography (ERT)

• Geophysical survey that can indicate subsurface geological conditions.
• Benefits for Accelerated Construction
  • Identify locations with high moisture content
  • Identify locations with unusual subsurface conditions
  • Timely decision making.
• Limitations and Availability
  • Experienced personnel are needed to collect and analyze the data.
  • Contact TTI for testing
    • Mark Everett, Dept. of Geology and Geophysics, Texas A&M University
Example - Equipment Information Sheet

Air Coupled Ground Penetrating Radar (GPR)

1 GHz antenna

**General Description**
- Vehicle mounted 1GHz antenna that transmits pulses of radar energy into the pavement. The system has an integrated high definition video logging system to provide images to complement the GPR data.
- Collects data at highway speeds. Traffic control is typically not required.

**Measured Properties**
- The antenna transmits electro-magnetic radar waves into the pavement at a frequency of 1 GHz. These waves are reflected at significant pavement layer interfaces and the system captures and displays these reflections as a plot of return voltage versus arrival time.
- Effective depth of penetration is 20 inches.

**Data Analysis**
- The software, PavéCheck, was developed by the Texas A&M Transportation Institute to assist with data analysis. The program integrates a video with a color plot of the waveforms. The program allows the user to:
  - Find anomalies visually.
  - Calculate layer thicknesses.
  - Calculate layer dielectric values.
  - Estimate locations of subsurface defects and the limits of the defects.
  - Estimate variations in surface density and the presence of subsurface moisture.

**Benefits for Accelerated Construction**
- Forensic investigations of existing pavement structures to help determine the appropriate maintenance or rehabilitation strategy.
- Engineers can make timely decisions due to the ease of data collection and analysis.

**Limitations and Availability**
- Some materials, such as light weight or slag aggregate, will give false positive indications of potential problem areas.
- The need for pavement coring is not eliminated; however, GPR data is helpful when developing a strategic coring plan.
- Experienced personnel needed to collect and analyze data.
- TxDOT currently owns 5 antennas.
Pavement Design Options – How fast can we build it?

Consider Traffic control options – time to work
Process For Traffic Control Scenarios

**PROCEDURE**

**STEP 1**
Identify “What-if” Scenarios

**STEP 2**
Estimate Project Duration

**STEP 3**
Assess Mobility Impact

**STEP 4**
Select the Most Feasible Option

**STEP 5**
Determine Risk Level

**STEP 6**
Adjust Project Duration in Step 2

**STEP 7**
Maximum Time Allowed

**INFLUENTIAL FACTORS**

- Lane Closure Options
- Construction Windows
- Rehabilitation Strategy
- Pavement Design
- Project Scope
- Value of Time
- AADT
- Agency Priority
- Resource Constraints
- Public Events & Concerns
- Potential Conflicts with Third-party
- Design Uncertainties
- Accelerated Production Rates (see Table 2-6)
- Weather Condition
- Weekends & Holidays
Construction Work Windows

Standard Work week
Five-Day Workweek
Six-Day Workweek
Seven-Day Workweek
Nighttime work
Continuous 24/7
Continuous Weekend
3-day continuous mid-week
How do we sequence the work to have the most efficient use of time?

- Experience
- Modeling Software such as CA4RPS
  - Research project 0-6985
Accelerate Construction?

Don’t Sacrifice Quality to Accelerate

STEP 5
Determine Risk Level

STEP 6
Adjust Project Duration in Step 2

STEP 7
Maximum Time Allowed

Public Events & Concerns
Potential Conflicts with Third-party
Design Uncertainties

Accelerated Production Rates (see Table 2-6)
Weather Condition
Weekends & Holidays
Summary

• Evaluate the Existing Condition
  • Incorporating the existing into new saves time, money and natural resources.

• Use data to make decisions
  • Testing is a small percentage of the Engineering Costs, while the pavement structure is the largest part of the Construction Cost.
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Perform Feasibility Study on Use of Innovative Tools and Techniques to Accelerate Pavement Construction

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<th>Email</th>
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</tbody>
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