2nd International Symposium on Non-Destructive Testing for Design Evaluation and Construction Inspection

25 April 2008
Ljubljana, Slovenia

Dr. Andrew Wimsatt – TTI
Dr. Monica Starnes – SHRP 2

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TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

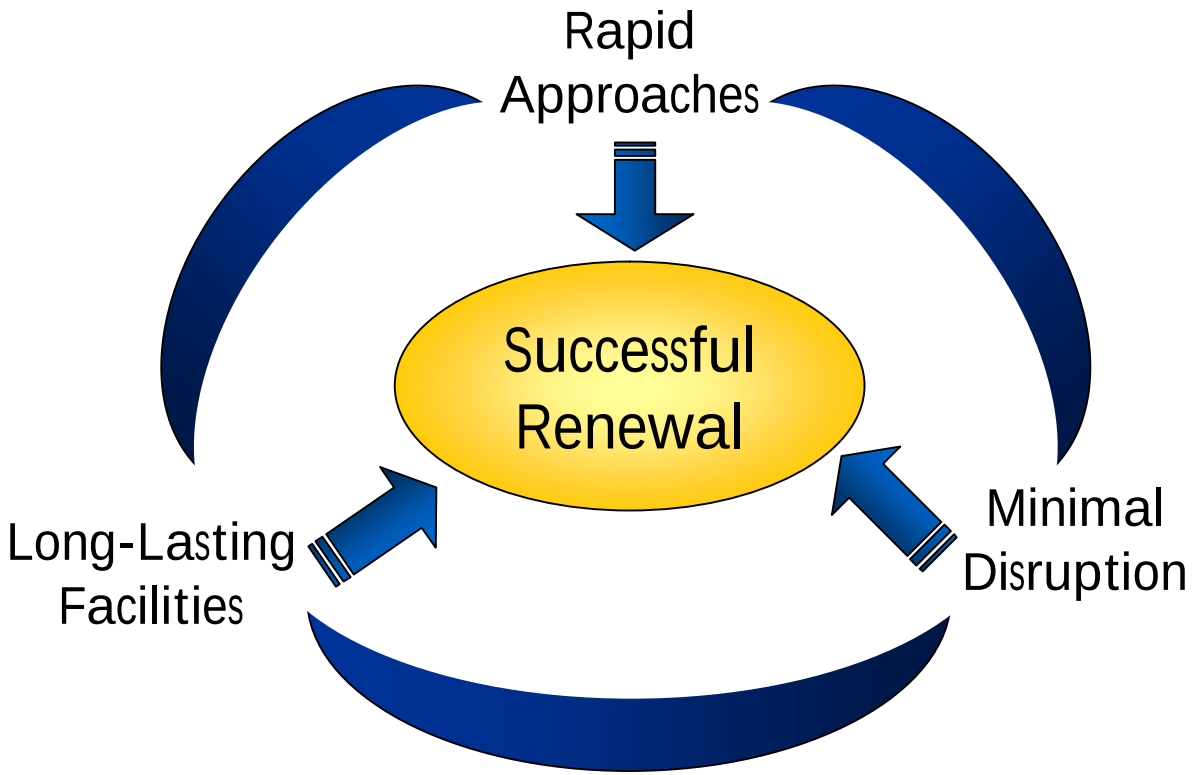
SHRP 2 Renewal Research

we are developing tools and techniques to facilitate a

“GET IN, GET OUT, STAY OUT”

strategic approach to highway renewal

Goals



To develop an approach to performing highway renewal that

- **is rapid**
- **causes minimum disruption**
- **produces long-lasting facilities**

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R06. Plan for Developing High-Speed NDT Procedures for Design Evaluation and Construction Inspection

May 2008

Goal

Developing a process to identify existing or, if necessary, to develop new and quickly implementable technologies

Anticipated Product

- ***Report* documenting**
  - Identification of **parameters that need to be measured**
  - **Plan to assess** applicability of **current promising technologies and techniques**
  - **Plan to develop new testing methods**

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Development of an R&D Plan with Focus on

- Highway Renewal
- NDT technologies that can produce results ideally in real time or at least within 48 hours.
- Emphasis on 100% coverage devices
- Emphasis on in situ testing

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Development of an R&D Plan with Focus on

NDT for three applications:

- Design
- Construction (QA Tools)
- Performance Monitoring

And the following highway components:

- Bridges
- Pavements
- Earthworks
- Tunnels
- Other Structures (i.e., retaining walls)

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Research Team

Texas Transportation Institute

Principal Investigator

- Andrew Wimsatt – bridges & pavements, forensics

Team

- Tom Scullion – pavements & bridges, forensics, NDT implementation
- Emmanuel Fernando – pavements, NDT implementation
- Roger Walker – system automation
- Stefan Hurlebaus – structural NDT & health monitoring
- Robert Lytton – NDT development & geotech
- Dan Zollinger – rigid pavements

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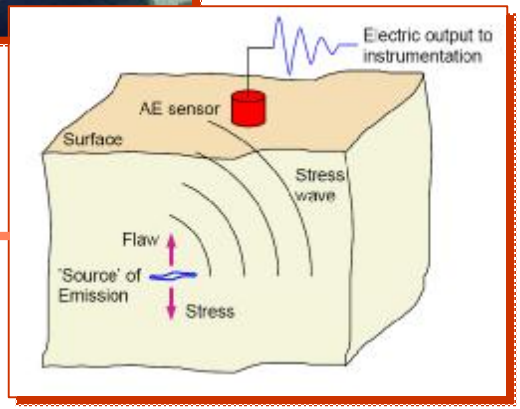
Information Gathering

- Literature review
- Questionnaires:
  - US Departments of Transportation
  - FEHRL
- Visits to six DOT's: California, Florida, New York, Minnesota, Texas, Washington
- Dialogue with academia, research labs, and NDT consulting industry
- 1st International Symposium on NDT

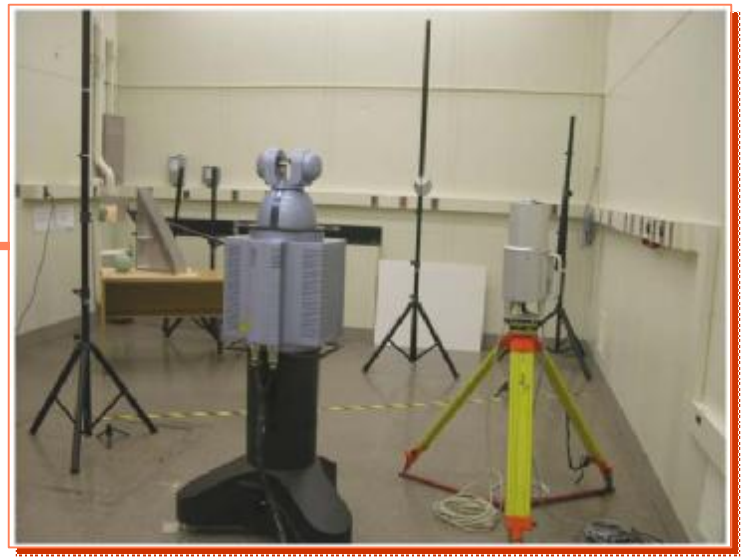
NDT used by U.S. agencies

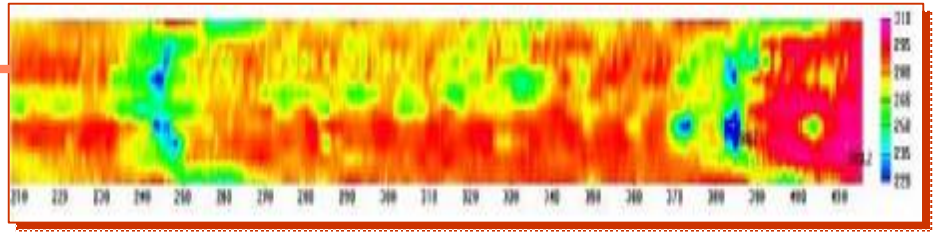
- Falling Weight Deflectometers
- Inertial profilers
- Nuclear Density Gauges
- MIT-Scan
- Friction (skid resistance)
- Profilographs
- Acoustic Emissions



NDT used by U.S. agencies

- Ultrasonic testing
- Laser scanning
- Magnetic particle testing
- Crosshole Sonic Logging
- Rebound hammer
- Covermeters or pachometers
- Ground Penetrating Radar
- IR





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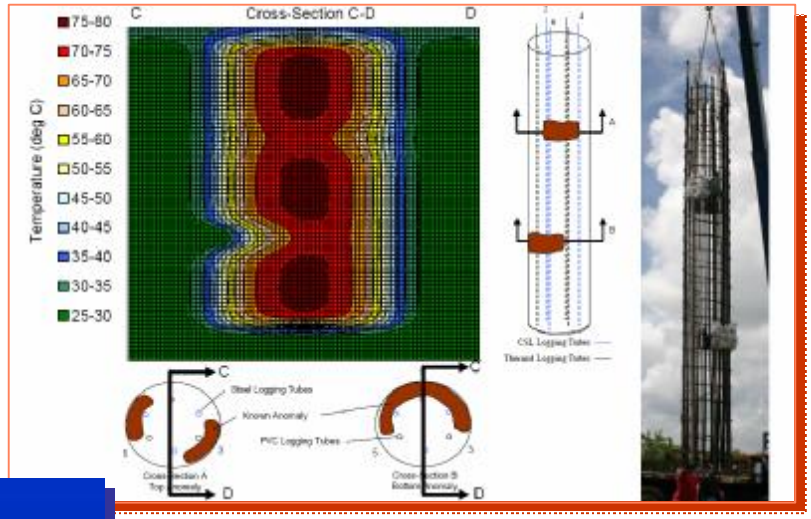
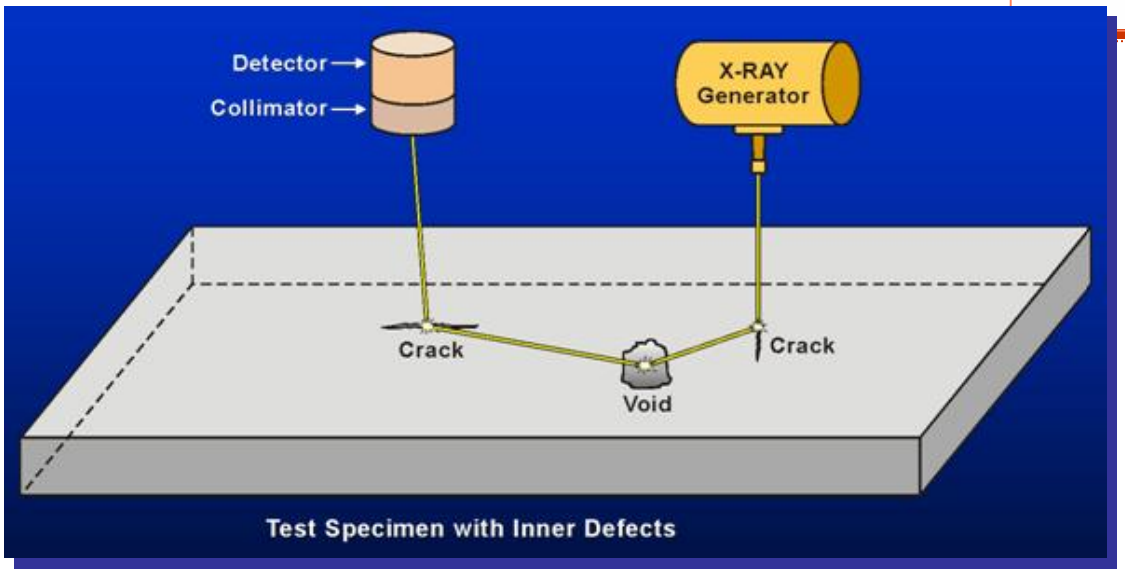
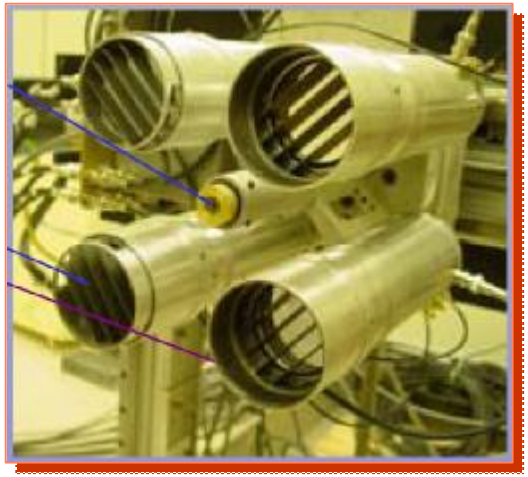
NDT under consideration by some U.S. agencies

- Thermal integrity testing of drilled shafts
- X-ray backscatter technology







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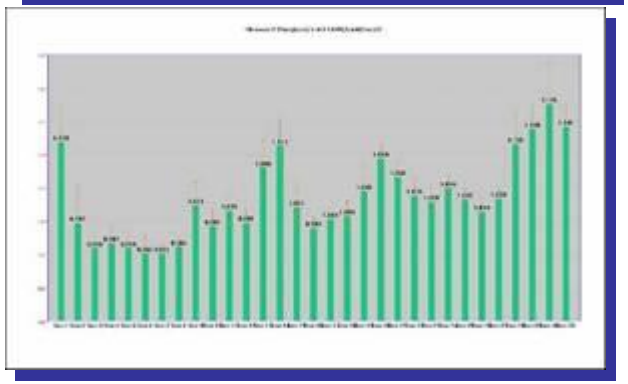
NDT under consideration by some U.S. agencies

- Intelligent compaction



- Sliding profiler

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Prioritization & Ranking

- How effectively does the recommended NDT address highway renewal needs?
- Could the technology or technique provide approximately 100% coverage?
- Would the NDT technology or technique be quickly implementable?
- Would the NDT technique result in significantly higher speed testing than is currently available?

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Top Recommendations for R&D

	Design	Construction	Performance
Automated methods of profiling bridges		Ò	Ò
Changes in tunnel profile over time			Ò
Identification of deterioration of bridge decks	Ò	Ò	Ò
High speed continuous deflection device for pavements	Ò		Ò
New NDT for construction QA		Ò	
Methods for pavement interlayer bonding	Ò	Ò	Ò

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Types of Projects Proposed

- Unfulfilled needs
  - Successful NDT technique still unidentified
- Experimental research
  - NDT need identified and several technologies could be used to address it
- Focused development
  - Promising technology where more development is needed
- Demonstration
  - NDT techniques implemented in a few agencies but not widely used

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Unidentified Techniques

	Design	Construction	Performance
Automated methods of profiling bridges		Ò	Ò
Changes in tunnel profile over time			Ò
Identification of deterioration of bridge decks	Ò	Ò	Ò
High speed continuous deflection device for pavements	Ò		Ò
New NDT for construction QA		Ò	
Methods for pavement interlayer bonding	Ò	Ò	Ò

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U1: Detecting Movement in Structures with Inertial Profile and Video Data

Focus on

developing a method for periodically monitoring profiles from bridges or other such structures by developing a data base of their characteristics.

Anticipated Products

- tool for collecting and analyzing network level bridge profile data for noting changes in these structures and how these changes can be used along with other NDT methods for determining bridge status

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U1: Detecting Movement in Structures with Inertial Profile and Video Data

- Task 1
  - Review recent R&D work of network level NDT video and profile systems
- Task 2
  - Develop and/or improve existing hardware/software needed for identifying the characteristics of the structure
  - Select set of bridges and gather current/past maintenance records and available profile/video data
  - Develop baseline signatures for selected bridges
  - Compare and evaluate surface profiles from previous years

U1: Detecting Movement in Structures with Inertial Profile and Video Data

- Task 3
  - Develop procedures for periodic monitoring of bridges using inertial profile and video data.
  - Work with at least one public agency and test procedure at their sites.
  - Refine procedures based on field testing
- Task 4
  - Document procedures, user's manuals for developed hardware/software.
  - Recommendations for implementation

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Experimental Research Project

	Design	Construction	Performance
Automated methods of profiling bridges		Ò	Ò
Changes in tunnel profile over time			Ò
Identification of deterioration of bridge decks	Ò	Ò	Ò
High speed continuous deflection device for pavements	Ò		Ò
New NDT for construction QA		Ò	
Methods for pavement interlayer bonding	Ò	Ò	Ò

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E1: Nondestructive Testing to Identify Delaminations between HMA Layers

Focus on

Identifying and **developing NDT methods and procedures capable of locating and characterizing areas of delaminations** between HMA layers

Anticipated Products

- Comprehensive review and documentation of existing procedures and equipment used
- Development and documentation of a rapid economical NDT method
- Documented field verification of recommended non-destructive testing procedures/equipment.

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E1: Nondestructive Testing to Identify Delaminations between HMA Layers

- Phase I
  - Review of NDT methods presently used
  - Proposal of a R&D plan to validate recommended methods
- Phase II
  - Modifications, if needed, to the recommended procedures/equipment
  - Controlled lab testing and validation
  - Field testing for those techniques proven to be successful in the first evaluation
  - Documentation of recommended technologies and procedures

Focused Development Projects

	Design	Construction	Performance
Automated methods of profiling bridges		ò	ò
Changes in tunnel profile over time			ò
Identification of deterioration of bridge decks	ò	ò	ò
High speed continuous deflection device for pavements	ò		ò
New NDT for construction QA		ò	
Methods for pavement interlayer bonding	ò	ò	ò

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F1: Nondestructive Testing to Identify Bridge Deck Deterioration

Focus on

Evaluating strengths and limitation of existing techniques, **identify best suited techniques, characterize accuracy and reliability on the field, develop protocols for most effective application**

Anticipated Products

- Documentation of existing procedures and equipment
- Development and documentation of a rapid, economical test or tests to be used to determine the presence, extent, and cause of deterioration
- Documented field verification of recommended non-destructive testing procedures/equipment

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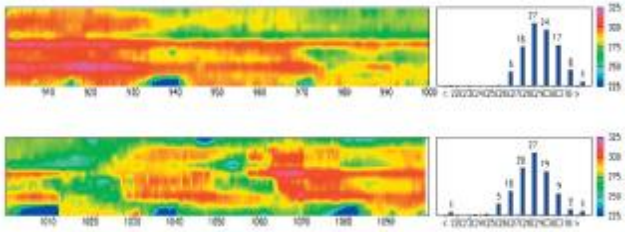
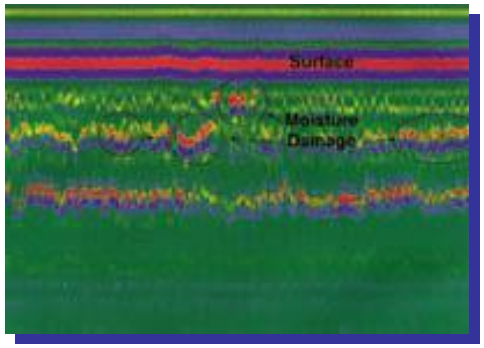
F1: Nondestructive Testing to Identify Bridge Deck Deterioration

- Phase 1 – Technology Assessment
  - Literature search
  - Evaluate existing systems in laboratory
  - Identify promising applications



- Phase 2 - Field Study
  - Demonstrate most promising applications in field
  - Characterize accuracy and reliability



- Phase 3 – Protocol Development

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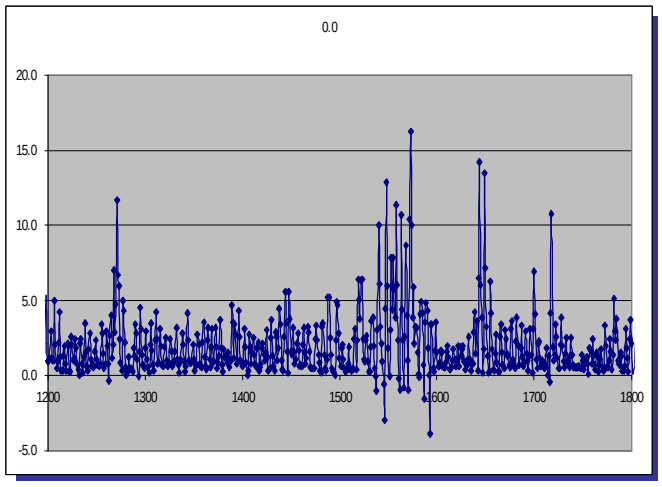
F2: Development of Continuous Deflection Sensors

Vibrosis Equipment



F2: Development of Continuous Deflection Sensors

- Devices available to put loads (vibratory or rolling wheel) on pavements
- Need for sensors and software to
  a) Measure pavement deflections at higher speed
  b) Remove surface noise from signal
  c) Measure movement on either side of joint

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F2: Development of Continuous Deflection Sensors

Focus on

Developing the next generation sensors for measuring concrete pavement deflections under load

Anticipated Products

- **New sensor array for a deflection device**
- **Data acquisition unit and data acquisition software**
- **User's Manual**

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F3: Using Field Spectroscopy Devices to Fingerprint Construction Materials

Focus on

- Evaluating the practical application of XRF, FTIR or RAMAN for quantitative analysis of paving materials
- Develop draft test protocols and equipment specifications

Potential Applications

- polymer content of asphalt
- quality and uniformity of lime and cements
- uniformity of asphalt emulsions
- sulfate content of soils

Anticipated products

- Recommendations on equipment availability, capabilities, reliability, cost, etc
- Test results from typical construction materials
- Draft test procedures

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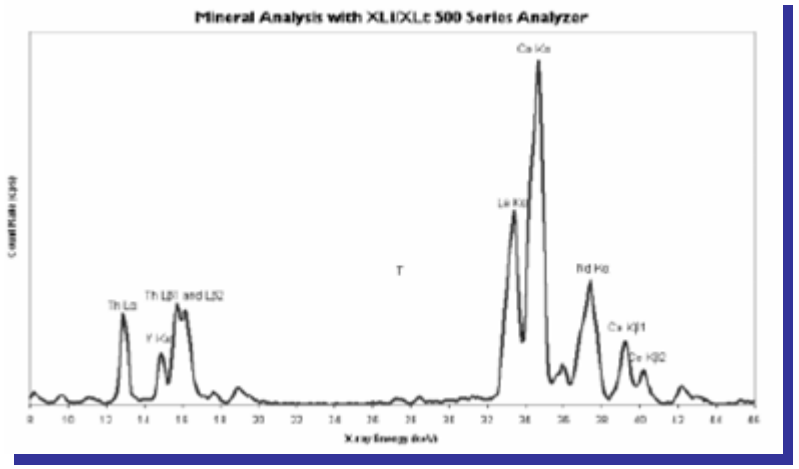
Field Spectroscopy Devices
XRF, FTIR, Raman

XRF x-rays
at atomic
level

Raman

(Laser
Excitation of
Molecules)

FTIR



INTENSITY COMPARED TO STANDARDS

F3: Using Field Spectroscopy Devices to Fingerprint Construction Materials

- Phase 1 - Lab Study
  - Evaluate existing commercial systems in laboratory
  - Identify promising applications
- Phase 2 - Initial Field Study
  - Demonstrate most promising applications in field
  - Recommendations on how to implement technology
  - Develop implementation plan and training materials
- Phase 3 - Implementation in DOT's
  - Purchase equipment for DOT use
  - Training program

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F4: Strength Determination and Integrity Evaluation of Concrete Pavement and Bridge Deck Repairs Using Seismic Techniques

Focus on

- **Improving existing seismic techniques** for this application
- **Developing the necessary correlations between seismic stiffness/wave speed and engineering properties** (strength and modulus of rupture)

Anticipated Products

- **Improved seismic techniques**
- Experimental **procedures** for establishing target levels for seismic stiffness values
- **Training materials** on the developed methodologies / implementation
- **Plan for implementation** of the developed methodologies

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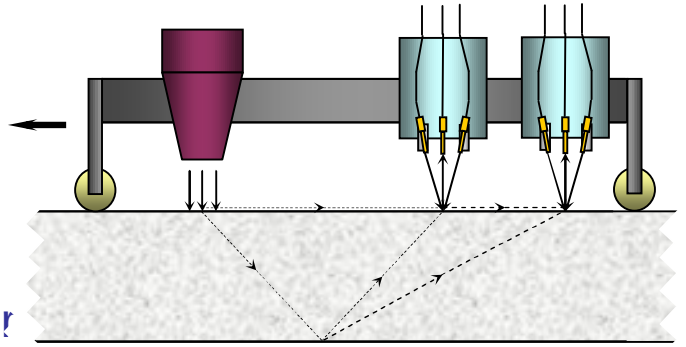
F4: Strength Determination and Integrity Evaluation of Concrete Pavement and Bridge Deck Repairs Using Seismic Techniques

Phase 1

- Review of promising technologies
- **Modify technique/technology as needed** to improve performance
- Use recommended seismic technique(s) on sever construction projects in one State
- **Validation testing** - validate that the NDT measurements do correlate with significant engineering properties
- Plans on how to conduct similar tests in at least five additional DOT's



Phase 2

- **Field testing** - Conduct tests at five DOT's
- Develop **training material** and recommendations for implementation

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F5: Real-Time Smoothness Measurements during PCC Pavement Construction

Focus on

- Developing new and/or improving existing technologies

Anticipated Products

- **Validated quality control methods** for smoothness measurements during concrete placement
- Application **guidelines**
- Process for technology implementation

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F5: Real-Time Smoothness Measurements during PCC Pavement Construction

Proposed Work Plan

- Technology review
- Test existing technology
  - Identify methods to test
  - Plan test program
  - Conduct tests
  - Identify additional development needs
- Perform development work
  - hardware
  - software
  - procedures
  - manual
- Test improved methods
- Recommendations for implementation

Demonstration Projects

	Design	Construction	Performance
Automated methods of profiling bridges		ò	ò
Changes in tunnel profile over time			ò
Identification of deterioration of bridge decks	ò	ò	ò
High speed continuous deflection device for pavements	ò		ò
New NDT for construction QA		ò	
Methods for pavement interlayer bonding	ò	ò	ò

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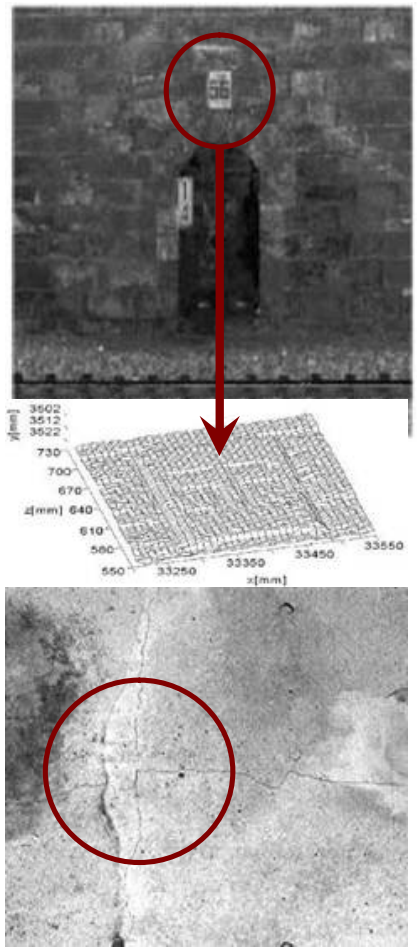
D/F1: Monitoring Change in Tunnel Profiles



Focus on

Identifying and improving NDT scanning systems and techniques to offer 100% coverage

Anticipated Products

- Validated NDE techniques for condition assessment and monitoring of tunnel linings
- Application guidelines
- Process for technology implementation

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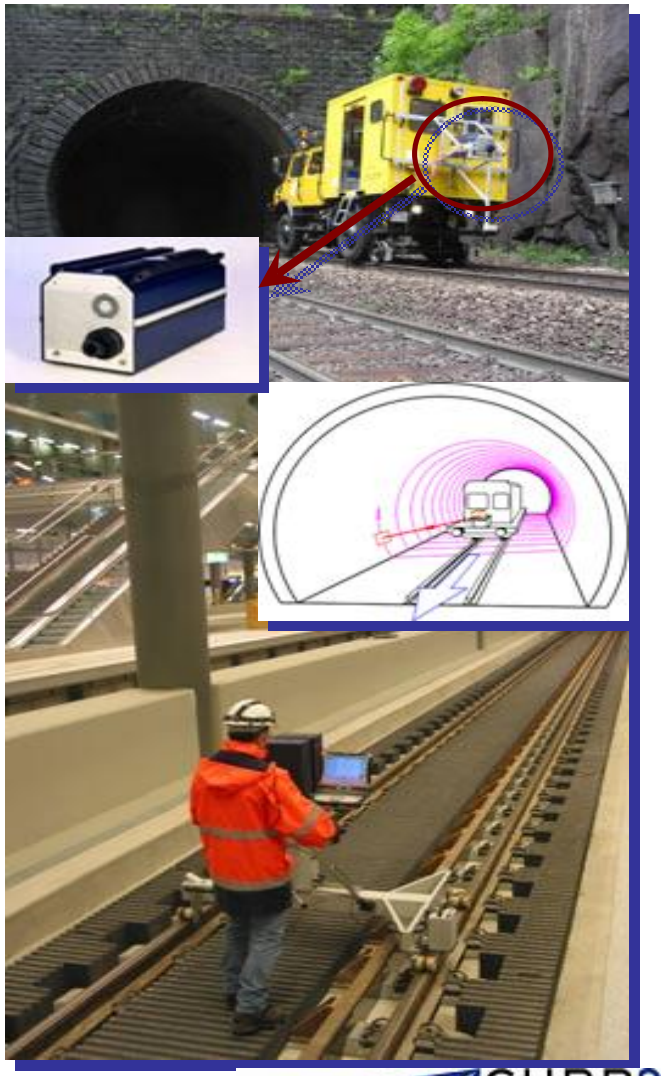
D/F1: Monitoring Change in Tunnel Profiles

- **Phase I - Demonstration**
  - Review state-of-practice
    - European experience
    - Japanese experience
  - Plan & conduct demonstration
- **Phase II - Development**
  - Development work, where needed (hardware, software, etc)
  - Verification testing of enhanced or modified tunnel laser scanning techniques
- **Phase III – Implementation Plan**



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D2: Infrared and GPR for Uniformity Measurements on New HMA Layers

Focus on

- Developing and field testing prototype specifications
- Demonstrating technologies to DOT's

Anticipated Products

- **Develop/refine test procedures**
- **Develop training materials**
- **Develop implementation plan**

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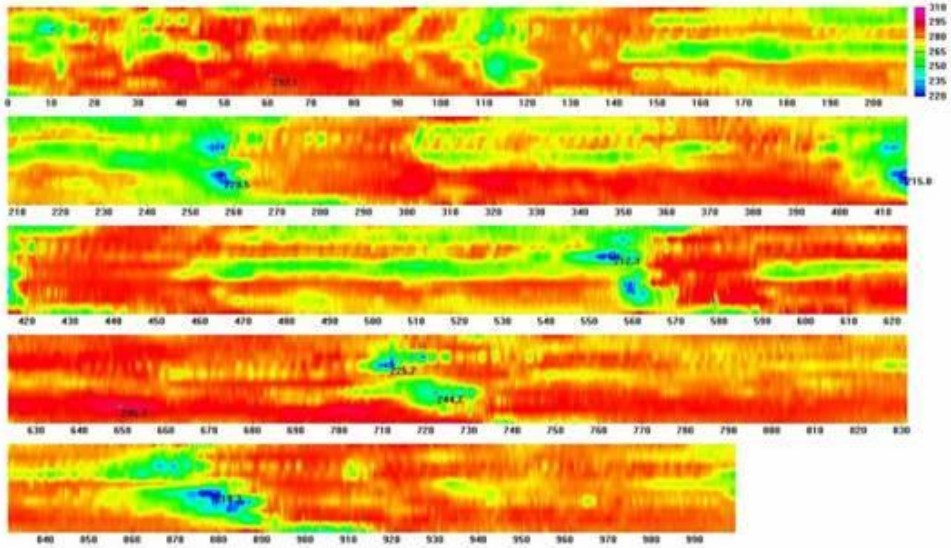
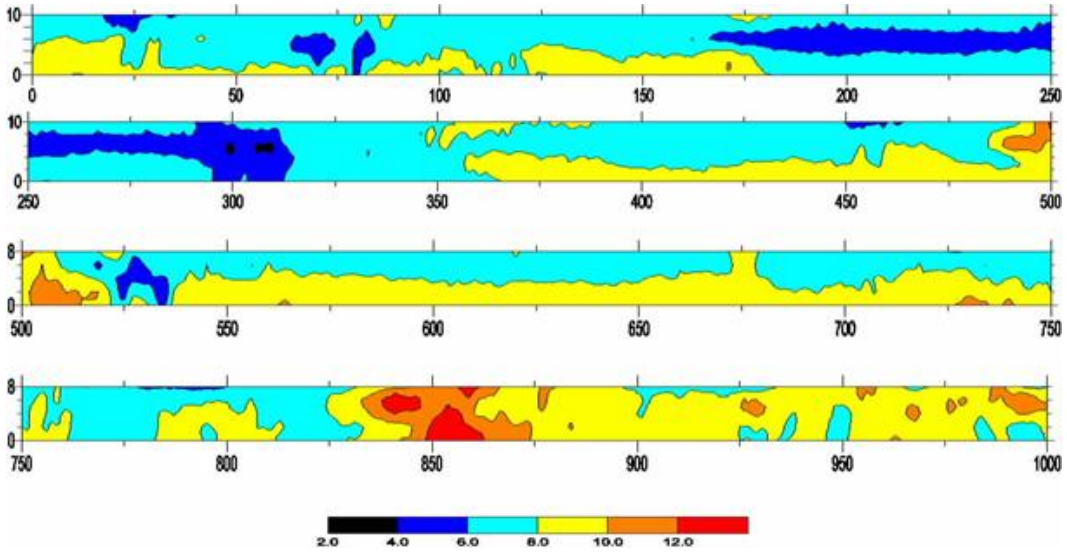


100% Coverage Devices for QC/QA testing of new HMA layers



D2: Infrared and GPR for Uniformity Measurements on New HMA Layers

- Phase 1
  - Evaluate and select equipment
  - Develop training materials
  - Demonstrate technology in one DOT
  - Perform validation coring
- Phase 2
  - Propose Draft Specifications
  - Demonstrate approach in additional DOT's
  - Provide Training
  - Develop framework for Operator and Equipment Certification

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D3: Smoothness Specifications Based on Inertial Profilers

Focus on

- Demonstrating technology to transportation agencies
- Development of tools for wide implementation

Anticipated Products

- Specifications
- Equipment and operator certification
- Training program and tools

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D3: Smoothness Specifications Based on Inertial Profilers

- Phase I
  - Document successful implementation of this technology
  - Plan demo projects
- Phase II
  - Conduct demonstration projects
  - Provide assistance in one or more of the following target areas:
    - Specification development
    - Equipment and operator certifications
    - Training
    - Shadow testing on pilot projects
  - Review of implementation experience and recommendations

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Top Recommendations for R&D

- **Unfulfilled Need**
  - Automated methods of profiling bridges
- **Experimental Research**
  - Methods for evaluating pavement interlayer bonding
- **Focused Development**
  - Identification of deterioration of bridge decks
  - High speed continuous deflection device for pavements
  - Field spectroscopy devices for construction QA
  - Seismic technique for QA of concrete pavement and bridge decks
  - Real-Time Smoothness measurements
- **Demo + Focused Development**
  - Changes in tunnel profile over time
- **Demonstration**
  - GPR + IR for testing HMA layers
  - Smoothness Specs based on Inertial Profilers

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Other projects considered

- Better NDT tools for mapping projects – Resistivity Mapping
- Validation Tools for QA of earthworks – Intelligent Compaction
- Validation tools for QA of drilled shafts – Gamma-Gamma Logging and Thermal Integrity
- Network of **National Calibration & Certification Centers**
- Foundation investigation tools – New technologies for mapping unknown bridge foundations
- Distress measurements
- Etc (up to 30 needs/potential projects identified in total)

THANK YOU

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