Recent Tunnel Incidents
Purpose of Tunnel Inspection

- Maintain safe tunnel operation
- Prevent structural, geotechnical, and functional failures
Tunnel Inspection Regulations

- NTIS: Similar to NBIS
- TOMIE Manual: Similar to BIRM
- SNTI: Similar to AASHTO Manual for Bridge Element Inspection and FHWA Coding Guide
National Tunnel Inspection Standards (NTIS)

Establishes:

- Method of inspections
- Interval between inspections
- Qualifications for inspection staff
- Inspection reporting and data requirements
- Procedure for national certification of inspectors
Tunnel Operations, Maintenance, Inspection and Evaluation (TOMIE) Manuel

- Establish procedures and practices for:
  - Inspection
  - Documentation
  - Priority classification of deficiencies
- New training course used *TOMIE Manual* Chapter 4 for curriculum development
Specifications for the National Tunnel Inventory (SNTI)

- Supplement NTIS and TOMIE Manual
- Provide specifications for coding data
- Submit to National Tunnel Inventory (NTI)
Critical Findings

A structural or safety-related deficiency that requires immediate follow-up inspection or action.
FHWA-NHI-130110
Tunnel Safety Inspection

• 5-day ILT including VTI and End-of-Course Examination
  • Assessment includes general knowledge and element level inventory and assessment

• Interactive
  • Audience Response System (ARS) activities
  • Group and individual activities
Course Table of Contents

- Module 1 – Overview of Tunnel Inspection
- Module 6 – Inspection of Electrical Tunnel Elements
- Module 2 – Tunnel Inspection Fundamentals
- Module 7 – Inspection of Signage and Lighting Tunnel Elements
- Module 3 – Inspection of Structural Tunnel Elements
- Module 8 – Inspection of Fire/Life Safety/Security Tunnel Elements
- Module 4 – Inspection of Civil Tunnel Elements
- Module 9 – Capstone Inspection Activity and Exam
- Module 5 – Inspection of Mechanical Tunnel Elements
Tunnel Shapes

- Rectangular
- Circular
- Horseshoe
- Oval/egg

Construction Methods

- Cut and cover
- Shield driven
- Bored
- Drill and blast
- Immersed tube
- Sequential Excavation Method
- Jacked tunnels
Tunnel Elements

Structural elements
- ceiling/roof, wall/liner, invert slab, slab-on-grade

Civil elements
- wearing surface, curb/barrier/safety walkway, railing

Mechanical elements
- ventilation, drainage, miscellaneous

Electrical elements
- power distribution, emergency power, electrical equipment

Signage and lighting elements

Fire/life safety/security elements
Inspection Scenario

• Participants asked to complete:
  • Inspection type
  • Inspection frequency
  • Planning and scheduling issues
  • Areas to inspect
  • What to look for
Structural and Civil Elements Defects

- Structural elements
  - Roof/ceiling/invert girders, ceiling slabs/panels, hangers/anchorage, liners, columns/piles, cross passageways, interior walls, portals, gaskets, invert slabs, slab-on-grade, joints

- Civil elements
  - Concrete/asphalt wearing surfaces, curbs, barriers, safety walkways, railings
Mechanical Elements and Defects

- Ventilation
  - Airways, sound attenuators, air quality monitoring equipment, control panels, and conduits, and dampers
- Drainage
  - Drains, piping, pumps/sump pumps, water treatment equipment, pump motors, pump controllers
Electrical Elements and Defects

- Switchgear
- Motor control centers
- Transformers
- Transfer switches
- Panelboards
- Conduits/raceways
- Electrical outlets/receptacles
- Emergency generators
- Uninterruptable power supply (UPS) systems
Signage and Lighting

Elements and Defects

- Traffic and pedestrian signs
- Variable message boards
- Lane signals
- Lighting fixtures
- Control panels and conduits
Fire/Life Safety/Security Elements and Defects
Inspection Methods

• Visual – surface deficiencies
• Physical – clean, measure, and document
• Operational – gather information about systems not evident through visual inspection
• Advanced – NDE and other
## Element Exercise

<table>
<thead>
<tr>
<th>Element Number and Name</th>
<th>Total Quantity</th>
<th>Unit</th>
<th>Quantities in Condition States</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>SNTI Tunnel Elements</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2600 Traffic Sign</td>
<td>2 (100)</td>
<td>EA (%)</td>
<td>1 (50)</td>
</tr>
<tr>
<td>2650 Variable Message Board</td>
<td>12 (100)</td>
<td>EA (%)</td>
<td>11 (92)</td>
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<tr>
<td>2675 Lane Signal</td>
<td>16 (100)</td>
<td>EA (%)</td>
<td>15 (94)</td>
</tr>
<tr>
<td>2676 Lane Signal Fixture</td>
<td>16 (100)</td>
<td>EA (%)</td>
<td>15 (94)</td>
</tr>
</tbody>
</table>
Virtual Tunnel Inspection Computer Based Training

- Participant are asked to inspect tunnel, identify elements, defects, and complete inspection forms
- Not practical to take 30 participants into actual tunnel
  - Developed Virtual Tunnel Inspection (VTI) Computer-Based Training (CBT)
VTI Inspector Equipment

Scenario:
You have completed confined spaces training and arrived on the scene to inspect a tunnel. The current weather is clear with a temperature of 65°.

Task:
Once you have selected all of the appropriate safety gear and applied the traffic precautions, you may begin inspecting.
You can come back to your truck at any time to adjust your gear, check traffic safety precautions, and view additional information.

Help:
Select the button to view the inspection environment help documentation.

Move User:
- Arrow Keys
- W, A, S, D Keys
- Left Mouse Button
- Direction Pad

Rotate User:
- Middle Mouse Button
- Rotation Pad

Magnify:
- Scroll Middle Mouse Button

Tool Menu:
- Right Mouse Button

Use Tool:
- Left Mouse Button
VTI CBT Upper Plenum Hanger
VTI CBT Mechanical Room
FHWA-NHI-130110
Tunnel Safety Inspection

• Pilot course: Baltimore, MD
• July 28 through August 1, 2014
• First course open for request after NTIS is published
Prerequisites

- FHWA-NHI-130054 "Engineering Concepts for Bridge Inspectors" - Instructor Led Training (ILT) or
- FHWA-NHI-130101 "Introduction to Safety Inspection of In-Service Bridges" - Web-Based Training (WBT)
- FHWA-NHI-130101a "Introduction to Safety Inspection of In-Service Bridges" (WBT) On-line Assessment
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Questions?