Inspection, Operation, and Rehabilitation Strategies for PennDOT Tunnels (P09-0372)
Tunnel Operations/Maintenance, Rehabilitation Strategies & Inspection Methods

Conduit Hanger Failure
Liberty Tunnel

Tunnel Fire in France

Ceiling Collapse at Ft. Pitt Tunnels
I. Tunnel Overview

Operations/Maintenance

Inspection, Operation, and Rehabilitation Strategies for PennDOT Tunnels
PennDOT District 11-0
Tunnel System

Consists of Four Tunnels:
- Ft. Pitt Tunnel (Built in 1960): 3614’
- Liberty Tunnels (Built in 1924): 5889’
- Squirrel Hill Tunnel (Built in 1953): 4225’
- Stowe Tunnel (Rebuilt 1940): 495’

Total Roadway Length:
14,223 ft.
Typically each of our district’s 3 main tunnels:

- Has a staff of 15 that works at the tunnel 24/7
- Tunnels are washed every two weeks
- Mechanical system: fans are checked weekly and maintained weekly (auto greasers)
- Light bulbs are checked constantly. When 10% are out, a crew is scheduled to change the bulbs.
- Tow truck is on site to clear accidents
- Emergency systems are checked monthly and a yearly walk through is held with the City of Pittsburgh EMS.
- Open and Close HOV gates
PennDOT 11-0: General Highway/Bridge Funding Philosophy

• In the past, typically focused on capacity-adding projects

• Now, focus on bridges and some on tunnels, resurfacing projects for highways

• Over $100 M/Yr. needed for Bridge Rehabilitation/Construction

• Limited Funding left over for tunnel needs
PennDOT 11-0: Historical Tunnel Funding

• **Liberty Tunnel**-
  Phase 1- $6.1 Million in 2008: Immediate Structural/Conduit
  Phase 2- $10 Million in 2009: Structural/Conduit
  Phase 3- $45 Million in 2010: Systems Upgrades & Remaining Rehab

  **Squirrel Hill:**
  $50 Million in 2010-2011: Structural Rehab/Life Safety Upgrades

• Prior to 2008 (Previous 32 years) we spent $33 million on tunnels:

  **Liberty Tunnel**- $12 million in 1975- $2 Million in structural repairs, $10 Million in 1996-replace roadway and barrier
  **Ft. Pitt Tunnel**- $20 Million in 2002)
PennDOT District 11-0: Rehabilitation Strategies
T-20 Manual for Design and Construction of Road Tunnels Vol. 1, Civil Elements
The European Tunnel Scan: “9 Recommendations” for Design and Rehabilitation of Tunnels
The European Tunnel Scan: “9 Recommendations” for Design and Rehabilitation of Tunnels

• Develop Universal, Consistent, and More Effective Visual, Audible, and Tactile Signs for Escape Routes

• Develop AASHTO Guidelines for Existing and New Tunnels

• Conduct Research and Develop Guidelines on Tunnel Emergency Management that Includes Human Factors

• Develop Education for Motorist Response to Tunnel Incidents

• Evaluate Effectiveness of Automatic Incident Detection Systems and Intelligent Video for Tunnels

• Develop Tunnel Facility Design Criteria to Promote Optimal Driver Performance and Response to Incidents

• Investigate One-Button Systems to Initiate Emergency Response and Automated Sensor Systems to Determine Response

• Use Risk-Management Approach to Tunnel Safety Inspection and Maintenance

• Implement Light-Emitting Diode Lighting for Safe Vehicle Distance and Edge Delineation in Tunnels
The Rehabilitation of an Existing Roadway Tunnel is accomplished by completing the following:

- Repair of all Structural, Roadway, Mechanical and Electrical Components that have deteriorated over the course of time.
The Rehabilitation of an Existing Roadway Tunnel is accomplished by completing the following:

- Repair of all Mechanical, Electrical, and Life Safety Components that have deteriorated over the course of time.
II. PennDOT District 11-0 Tunnel Rehabilitation Strategies, Continued
Typical Tunnel Rehabilitation Items

- Tunnels are rehabilitated about every 40 years.
- Roadway repairs inside the tunnel are done every 10 years.
Ft. Pitt Tunnel Rehabilitation - 2002

**NEW TUNNEL**
- Right Barrier 2’-0’
- Left Barrier 2’-0’
- Lanes 2 - 12’-0”
- Curb Gutters 2 – 5”
- Vertical Clear 14’-1”

**EXISTING TUNNEL**
- Right Curb 1’-7”
- Left Curb 3’-5”
- Lanes 2 - 11’-6”
- Curb Gutters 2 – 5”
- Vertical Clear 13’-10”

$20 M Total Construction Cost
Fort Pitt Tunnel
Major New Components

- Tunnel Luminaire
- HPS Point Source Lighting
- Closed Circuit Television Camera
- Increased Vertical Clearance
- Increased Roadway Width
- New Roadway Barriers
- New Feature
Ft. Pitt Tunnel
Roadway Construction

Completed Barrier and Roadway Demolition in left lane

Roadway Barrier placement by Slip forming
Ft. Pitt Tunnel Wall Repair Details

- Delaminated ceramic tile repair on ceiling and walls
- Tunnel wall expansion joint repair area to replace concrete and correct wall drainage problem
Liberty Tunnel Rehabilitation

• Currently underway:

• Phase 1 (2008): Outbound Tunnel- Wall and Conduit Repair - $6 M

• Phase 2 (2009): Inbound Tunnel- Wall and Conduit Repair - $10 M

• Phase 3 (2010): Complete Tunnel Systems Upgrade- $45 M
Liberty Tunnel Rehabilitation

Hydro-demolition Operations
Liberty Tunnel Rehabilitation

Shotcrete Operations
Liberty Tunnel Rehabilitation

Shotcrete Operations
Liberty Tunnel Rehabilitation

Finished Concrete Repairs
Squirrel Hill Tunnel Rehabilitation

- Scheduled for 2010
- Projected $50M program; Consultant selected, ready to proceed to design.
- Construction to begin 2011.
Lessons Learned

1) Tunnel Rehabs can be very expensive.

2) Project Phasing should be considered.

3) Consider night and weekend work for High ADT Tunnels.

4) Rehabs are opportunities for Life Safety System upgrades.

5) Hydro-demolition is a good technique to remove deteriorated concrete from tunnel ceilings.
III. Tunnel Inspection/Rehabilitation

Background - Existing Guidelines

Inspection, Operation, and Rehabilitation Strategies for PennDOT Tunnels
PennDOT 11-0: General Tunnel Inspection Methodology

- Typically performed at 2 year intervals
- No separate tunnel format. Data is entered into regular Bridge Mgmt. System (I-Forms) then deleted for FHWA reporting
- Tunnel assets treated “as bridges”
AASHTO Subcommittee on Tunnels (T-20) has been tasked with the following:

- Develop and Maintain Specifications
- Develop Highway Tunnel Management Systems for AASHTO approval
- Identify Research Needs and recommend Research Problem Statements
## AASHTO Subcommittee on Tunnels (T-20) Strategic Roadmap

### Strategic Roadmap For Tunnels

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### Committee Members

- [List of Committee Members]

- [President: John Doe]

- [Vice President: Jane Smith]

- [Secretary: Michael Brown]

- [Treasurer: Sarah Johnson]

- [Other Committee Members: [List of Members]]
Basis for Development of Rehabilitation Plans

- **The US House of Representatives Resolution HR 3999** - National Highway Bridge Reconstruction and Inspection Act of 2008

- A survey was sent out Nov. 18, 2008 to all the states for the purpose of soliciting comment creation of a regulation establishing National Tunnel Inspection Standards.
• In-Depth Inspections are conducted to determine the quantity and extent of defective areas.
• Additionally, Smoke Testing, Fan Testing, Electrical Component Inspection is also performed.
• FHWA Inspection Manual is useful guide for rating system but is not all-inclusive.
IV. Demonstration of PennDOT 11-0 Inspection and Rehabilitation Planning using TMS
TMS- Tunnel Management Software

TMS Overview

• Designed to allow Tunnel Owners to monitor the physical condition of their tunnel assets

• Designed to be used over time to identify trends in performance/maintenance

• Provides variety of data through graphical point-and-click method
TMS- Tunnel Management Software
PennDOT 11-0 System Map
TMS- Tunnel Management Software
Tunnel “Keyplan”- Data Overview
TMS- Tunnel Management Software
Inspection Functionality

- Facilitates a much more comprehensive inspection documentation/record keeping system

- Requires some foresight in data collection methodology and file organization

- Essentially all of the inspection report data, typical condition reports, photos, etc. appear in system.
TMS- Tunnel Management Software Development Of Rehabilitation

- TMS tabulates data for ease of compilation and reporting
- Used to prioritize repairs
- Some limitations on operations on data - i.e. sorting and specified reporting
TMS- Tunnel Management Software

Output/ Maintenance

- Use data output to track repairs, and costs
- TMS incorporates ability to track incidents and maintenance expenditures
V. Presentation of Suggested Enhancements to the T20 Unified Inspection Methodology and TMS Software
Suggested Enhancements

- Standardization of Tunnel Inspection Documentation and ratings systems
Suggested Enhancements

- Integration with Existing Bridge/Tunnel Inspection Programs
Suggested Enhancements

- Condition Tracking/Inspection Needs vs. Maintenance/Operation Functionality
Suggested Enhancements

- Inclusion of Mechanical/Electrical Tracking-Assessment Capabilities
Suggested Enhancements

- Online Repository of New or Rehabilitation Tunnel Projects
VI. Questions