Pedestrian Tunnels
The Mode of the Future
By Don Del Nero, PE, CDT
Agenda

1. Introduction
2. Thin Cover Tunneling Methods
3. Tunnel Design Factors
4. Case Histories
5. Risk Management
1 Introduction

Winnipeg CPR Arlington Rail Yard

Stantec Study Won ACEC Award!
Barrier Effect on Animal Populations

Natural or Man-made Barrier

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Pedestrian Tunnels

Potentially the most transformative transportation project being constructed today!
Primary Genesis for Bike/Ped Tunnels

Trails!

- Bike/Ped trail programs in all 50 states*
- Scores of trails in Europe and Asia*
  - Over 617 trails in US*
- Over 278,000 km of trails in Canada**
  - 77 rail to trail tunnels***
- Camp Chase Trail – Franklin County, OH!

*Wikipedia as accessed September 27, 2017
**Canadian Trails Study, December, 2010, National Trail Coalition
*** Rails to Trails Conservancy, 2001
Pedestrian Tunnel Versatility

Combinations abound…

- Rail – Whittier Tunnel
- ATV’s
- Wildlife
- Pets
- Cyclists
- Joggers
- Marathoners
- Equestrian – Carver Tunnel
- Snowmobiles
- Golf Carts
- Fish Channels
2 Thin Cover Tunneling Methods

Stantec's Knowles Ave. Pedestrian Underpass
Stantec's Malvern Station AMTRAK and SEPTA Pedestrian Crossing
Thin Cover Tunneling Methods

- Cut-n-Cover
- Pipe Ramming
- Square Microtunneling
- Hand Mining
- Road Headers
- Jacked Open Shields w/Breasting Tables
- Digger Shield
- Cellular Arch Method
- ADECO Method

- Jacked Box Tunnel
- Pulled Box Tunnel
- Sequential Excavation Method w/ & w/o Pipe Roof Canopy
- Drill & Blast
- Mutual Tugging Method
- Stacked Drift Method
- Concrete Tube Method
Pipe Ramming

- Pneumatic Percussion System
- Thin-walled Pipe Hammered/Driven into Place
- Horizontal Pile Driving Technology
- Limited Soil Displacement

*Courtesy of Miller the Driller*
Sequential Excavation Method

- Conventional Tunneling Method Used for Soil and Rock Tunnels
- Uses Internal Steel Supports and Shotcrete (sprayed concrete) for Support of the Ground
- Cast in Place Concrete Lining Typically Placed Inside Tunnel
Jacked Box Method

• Concrete Box is constructed and jacked through ground while excavation of material is completed.
• Typically used for Short and Shallow Tunnels with overlying roads or railroad tracks.
Pipe Roof Canopy

- Uses microtunneling or pipe-ramming techniques to install a pre-support canopy of steel pipes.
- Tunnel is excavated within the protection of the completed pipe roof canopy.
- Early 1990’s, 5 feet between top of tunnel and road surface.
Cut & Cover – Bottom Up

- Trench Excavated From the Surface
- Tunnel Constructed
- Tunnel Backfilled and Surface Restored
- Ground Support (SOE)
  - Sloped Sides
  - Internally Braced Walls
  - Tieback Wall

After DOT FHWA Tunnel Manual
Cut & Cover – Top Down

- Tunnel Walls Installed First
- Tunnel Roof Constructed
- Tunnel Backfilled and Surface Restored
- Remainder of Tunnel Construction Completed
- Ground Support (SOE)
  - Secant Pile Walls become part of permanent structure

After DOT FHWA Tunnel Manual
Hand-Mining
Relative Construction Cost*

- Square Microtunneling
- Pulled Box Tunnel
- Jacked Box with Anti-drag System
- Jacked Box Tunnel
- Mutual Tugging Method
- Cellular Arch Method
- Sequential Excavation Method w/Pipe Roof Canopy
- Sequential Excavation Method
- Digger Shield
- Road Headers
- Jacked Open Shields
- Pipe Ramming
- Hand Mining
- Cut-n-Cover

*Length, dia, cover, and ground conditions can alter order
3 Tunnel Design Factors
## Tunnel Design & Construction Factors

### Design Factors
- Length
- Diameter
- Invert Width
- Cover Thickness
- Above Surface Utilization
- Tunneling Performance Envelope
- Pedestrian Volumes
- Disability Provisions
- Line & Grade
- Inert Width
- Potential Embankment Debris
- Headwall Design
- Potentially Contaminated
- RR, DOT, MOT, and Commuter Agency Codes
- Ground Improvement
- Crossing Orientation
- Sidewall Facade
- Headwalls
- Architectural Elements
- Human Tolerance Factors
- Connectivity Needs
- Safety
- Train Width
- Vehicle Width
- Speeds
- Tunnel Industry Experience
- Project Delivery Method
- Ground Conditions
- Ground Behavior
- Vibration
- Noise
- Instrumentation

### Design Factors
- Ground
- Size of Staging Areas
- Construction Duration
- Constraints
- Visual/Aesthetics
- Jacking Loads
- Thrust Block Design
- Risk Management
- Contract Tools
- Pipe or Bar Spiling Design
- Muck Disposal
- Quality of Record Information
- Lighting
- Ventilation
- Drainage
- ROW Limits
Human Tolerance Factor Rating System (HTFRS)

- Stantec Developed Assessment Tool
- Qualitative System
- Mix of Subjective and Objective Factors
- Facilitates Evaluation of How User Friendly a Ped Tunnel is
- HTF Rating System
- HTFRS Rating Factors
  - Height, Length, Diameter, Slope, Shape, Lighting, Ingress/Egress Provisions, Aesthetics, Safety, Ventilation, Surrounding Land Use, Final Finish, & Location
Human Tolerance Factor Rating System (HTFRS)

- **HTF Rating System**
  - Unacceptable – Pedestrians Avoid Tunnel
  - Uncomfortable – Periodic Use Only To Avoid Other Temporary Blocked Route
  - Comfortable – Tunnel used often
  - Welcoming – Tunnel is an Attraction
Human Tolerance Factor - Rudimentary Example

- Height is a stronger factor in "friendliness" than width.
Human Tolerance Factor

Pedestrian/Equestrian Tunnel – 600 ft. Long, Approx.
20 ft. High and 16 ft. Invert

Rating

Uncomfortable

- a horse in the tunnel will almost completely block the opening
- no lighting
- length creates a claustrophobic feeling
- timber finish nice feature
Human Tolerance Factor

Pedestrian/Bike Tunnel

- a bike in the tunnel creates an unsafe feeling
- final finish is rough shotcrete

Rating

Uncomfortable
Human Tolerance Factor

Pedestrian/Equestrian Tunnel – 1,500 ft. Long, 24 ft. Wide, 30 ft. plus Height

Rating

- wide invert
- good height
- rock face will attract users

Comfortable
Human Tolerance Factor

- Welcoming
  - Nice façade
  - Safe
  - Architectural features
  - Artistic features
  - Relatively short length
  - Trees
4 Case Histories
City Fort Collins Pedestrian Tunnel Under BSNF
14’ Día./75’ Pedestrian Tunnel

Key Features:

• Alternative project delivery
• 200-page submittal to BNSF
• 9-month permitting phase
• Jacked shield with sand shelves
• Brick debris in embankment
• Custom fabricated sand shelves
• Custom designed jacking/thrust wall
• 2.5 ft./day advance rate – 8 hr. shifts
• 14 ft. dia. pipe, 1 ½ in. wall with internal welding, 8 ft. long sections
• 1,100 ton, 5 ft. thick concrete thrust wall
• Bentonite lubrication
• Soil and weak limestone
Carver Pedestrian Tunnel
KYTC
(1,500’ L, 20’ W, 50’ H)

Key Features:
• Multiple tunnel collapses
• Unique subsurface investigation solutions
• Unique bid item make-up to account for variability
• Rudimentary support system to preserve antiquity value
• Rock dowels and mesh support
• Preserve antiquity value
Before
After
5 Risk Management
Risk Factors

- Complex & Widely Varying Subsurface Conditions
- Limited Horizontal Investigation Methods
- Non-engineered Embankments
- Debris
- Excessive Settlement
- Thin Cover
- Bad Ground
- Loss of Commerce
- Tunneling Technology Limitations – Exotic Methods
- DOT & RR Experience Gap
- Protracted Permitting Process
- Construction Impacts
- Socio-Economics
- Stakeholders Acceptance
Risk Management Philosophy

Risk Shedding...
• All risks allocated to contractor
• Contractor owns the ground
• No contract risk tools

Consequences...
• Contingencies increase
• Bid prices increase
• Misunderstandings increase
• Claims increase
• Overall costs increase
• Reduced bidder pool
• Increased bid scatter

Risk Sharing:
• Owner assumes ground risk more severe than baseline

Tools:
• Geotechnical Data Report
• Geotechnical Baseline Report
• Escrow Bid Documents
• Value Engineering Change Proposal
• Differing Site Conditions Clause
• Risk Review Panel
• Dispute Resolution Board
• Risk Register
Thank you very much!

don.delnero@Stantec.com
678-227-0189