A State-of-the-Art of Underground Construction In Urban Areas

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Underground Construction

- Transit
- Rail
- Highways
- Water Conveyance
- Utilities
- Power
- Mining
- Special Projects
Construction Techniques

- Cut and Cover
- Hard Rock Tunnels
- Soft Ground Tunnels
- Tunnel Boring Machines
- Sequential Excavation or New Austrian Tunneling Method
- Box Jacking
- Immersed and Floating Tunnels
- Ground Improvement
- Micro Tunneling
- Shaft Construction
Initial Segment of NYC Subway

Union Square, New York City, circa 1904

... by
Gen. William B. Parsons –
US Army Corps of Engineers
Cut and Cover

LA Metro

Internal Bracing and Decking
Rock Tunneling

Yucca Mountain Repository - Nevada
...Rock Tunnels

63rd Street Subway Line – New York
Roadheaders

ESA Project – New York

Montreal Metro
Soft Ground Tunnels

Earth Pressure Balance TBM (EPB)

Slurry TBM
Earth Pressure Balance TBM

Los Angeles MTA Eastside Extension EPB TBM
Earth Pressure Balance TBM

Singapore Deep Tunnel – 7.2 m
... Singapore Deep Tunnel
Seven TBMs
Simultaneously 4.4 to 7.2 m

Commenced Tunneling Apr 01
Completed Tunneling Dec 02

Contract T03
Tunnel Length
5150m (16900 ft)
TBM Diameter
7.2m (23.7 ft)

Record progress
In a month
536 m or 1658 ft
...EPB Binocular TBM

Shanghai Metro
Slurry TBM

Shanghai Highway Tunnel – 13.2 m
...Slurry TBM

Cairo Metro (9.4 m)
Slurry TBM
West and East Sides CSO Tunnel, Portland

- **West Side Tunnel**
  - 2003 - Present
  - 5,500 m (18,000 ft) long
  - Two drives
  - 4.9 m excavated diameter
  - 5 shafts (12 to 16 m dia)
  - Crosses 6 major bridges

- **East Side Tunnel**
  - Start 2006
  - 8800 m (29000 ft)
  - 6.7 m diameter (22 ft)
... Scenes from the Portland Westside CSO Project
Tunnel Linings – State-of-the-Art in Precast Segments
New Austrian Tunneling Method

Caldecott Highway Tunnel San Francisco
... NATM – Beacon Hill Station - Seattle

Beacon Hill Station - Seattle
Vienna Metro Section U2/3
Pre-Support Measures

- Spiles
- Steel Sheets
- Grouting

Grouting
Cavern Construction

Parramatta Line - Sydney
• Concourse and platform caverns
• Platform cavern 210m L x 20m W x 18 m H
... Cavern Construction

Weehawken Station HBLRT

Peachtree Station - Atlanta
Final Liner
Shaft Construction

Slurry Wall Shaft

Secant Piles Shaft
...Shaft Construction

Segmental Shaft Boring Machine

Raise-Bore
Immersed Tube Tunnels

Ted William Tunnel - Boston
...Immersed Tube Tunnels

Fort Point Channel Tunnel - Boston

Bosporus Crossing
Tunnel Jacking

Central Artery Under South Station - Boston
Ground Improvement

- Jet Grouting
- Permeation Grouting
- Chemical Grouting
- Deep Soil Mixing
- Freezing
Tunnel Systems

- Railroad Systems (tracks, signals, power, communications, Control, etc...)
- Highway Systems (traffic control, signs, power, communications, etc...)
- Tunnel Ventilation / Environmental Control Systems
- Tunnel Fire Life Safety
- Tunnel Lighting and Power
- Drainage
- Control Centers
- Safety and Security
Environmental Performance Criteria

- **Normal Operations**
  - Temperatures (summer, winter)
  - Pressure Transients (On Board, Way Side)
  - Air Velocities

- **Emergency Situations**
  - Back-layering
  - Critical Velocity
  - People Evacuation

- **Numerical Modeling**
  - SES, CFD, Simulex, etc..

- **Memorial Tunnel Fire Test Program**
Push-Pull Ventilation

Amtrak North River Tunnel Ventilation Shaft
Ventilation Environmental Control System

Station Exhaust

Platform Screen Doors
Design of Tunnels for Extreme Events
What’s Next…

World’s Largest TBM 15.2 m
What’s Next....

The Monster....
Multi Micro Shield (MMS)

27 m x 24 m Rectangular Tunnel
If You Can Dream It, You Can Build It....

Battery locomotion

Erector

Sequence of installation
One Final Thought.....

Technologies do not build tunnels...
People do!

Thank You!