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TRANSPORTATION RESEARCH FORUM

March 2006

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

Nasri Munfah PE
Vice President
Tunneling Practice Leader
Parsons Brinckerhoff





Underground Construction

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



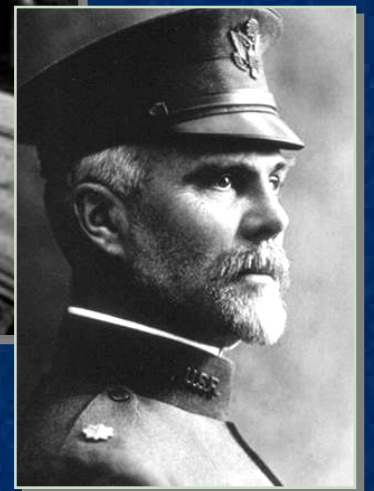
Construction Techniques

- 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



Timore



Internal Bracing and Decking

...Cut and Cover



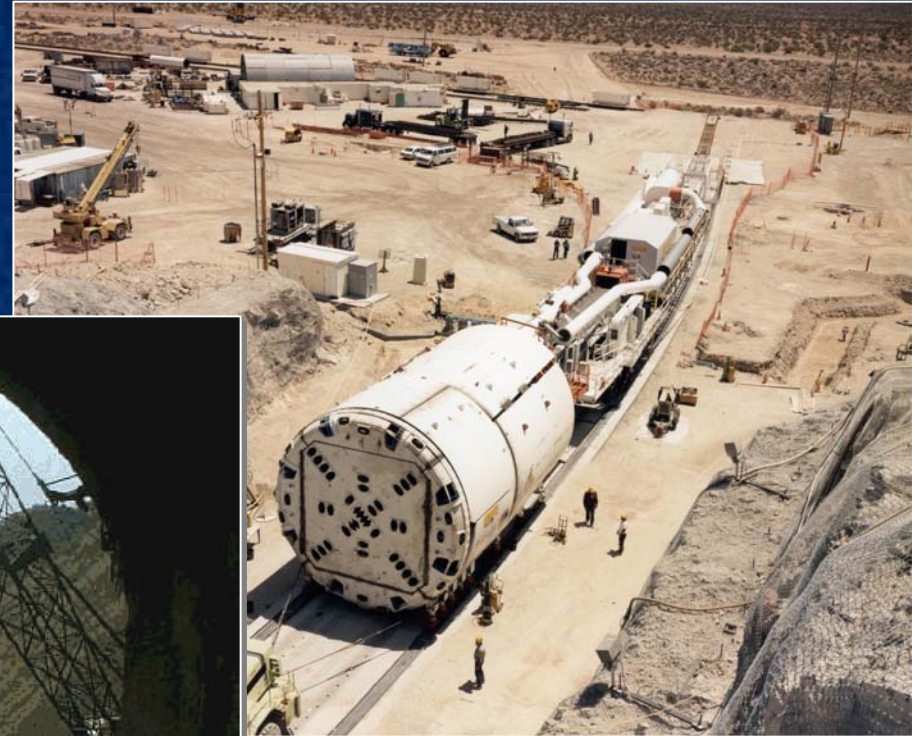
63rd Street Connection Project - NY



... Cut and Cover Impacts Daily Life

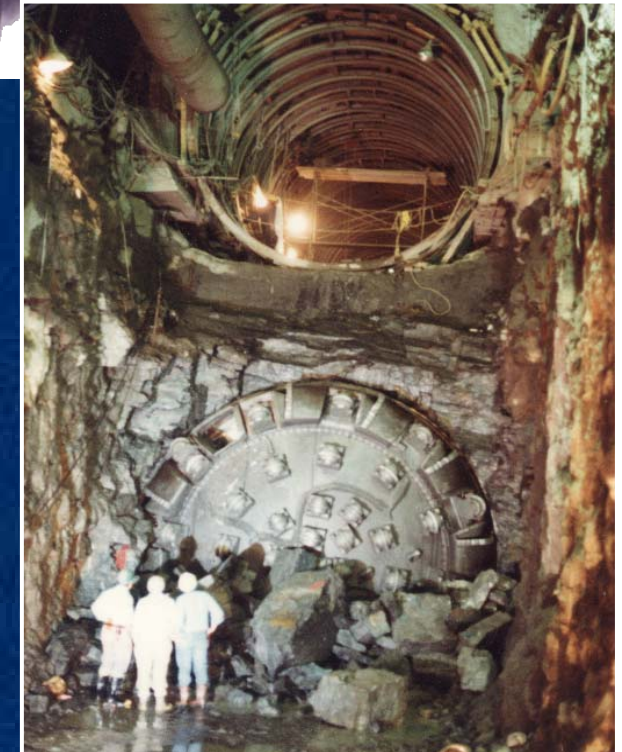
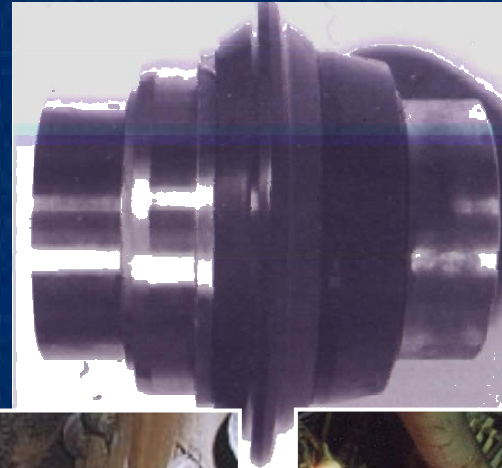


Rock Tunneling



Yucca Mountain Repository - Nevada

...Rock Tunnels



63rd Street Subway
Line – New York

Roadheaders

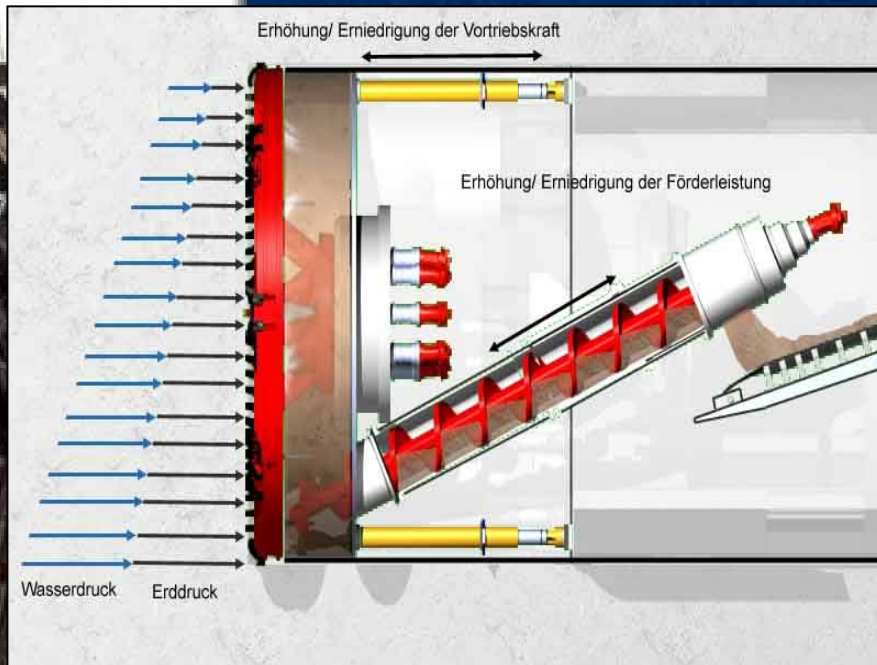


ESA Project – New York

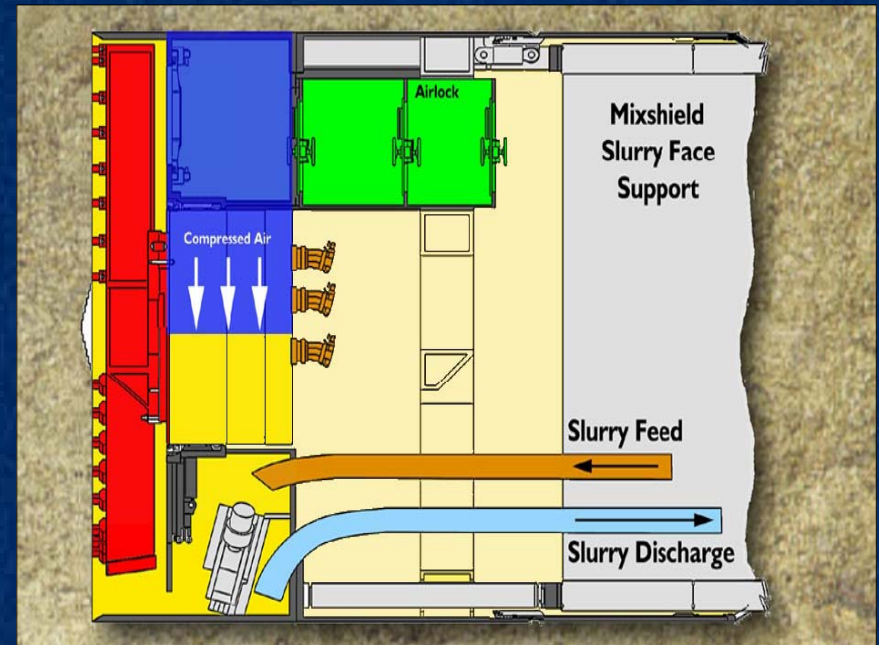


Montreal Metro

Soft Ground Tunnels



Earth Pressure Balance TBM (EPB)



Slurry TBM

....Earth Pressure Balance TBM



Los Angeles MTA Eastside Extension EPB TBM

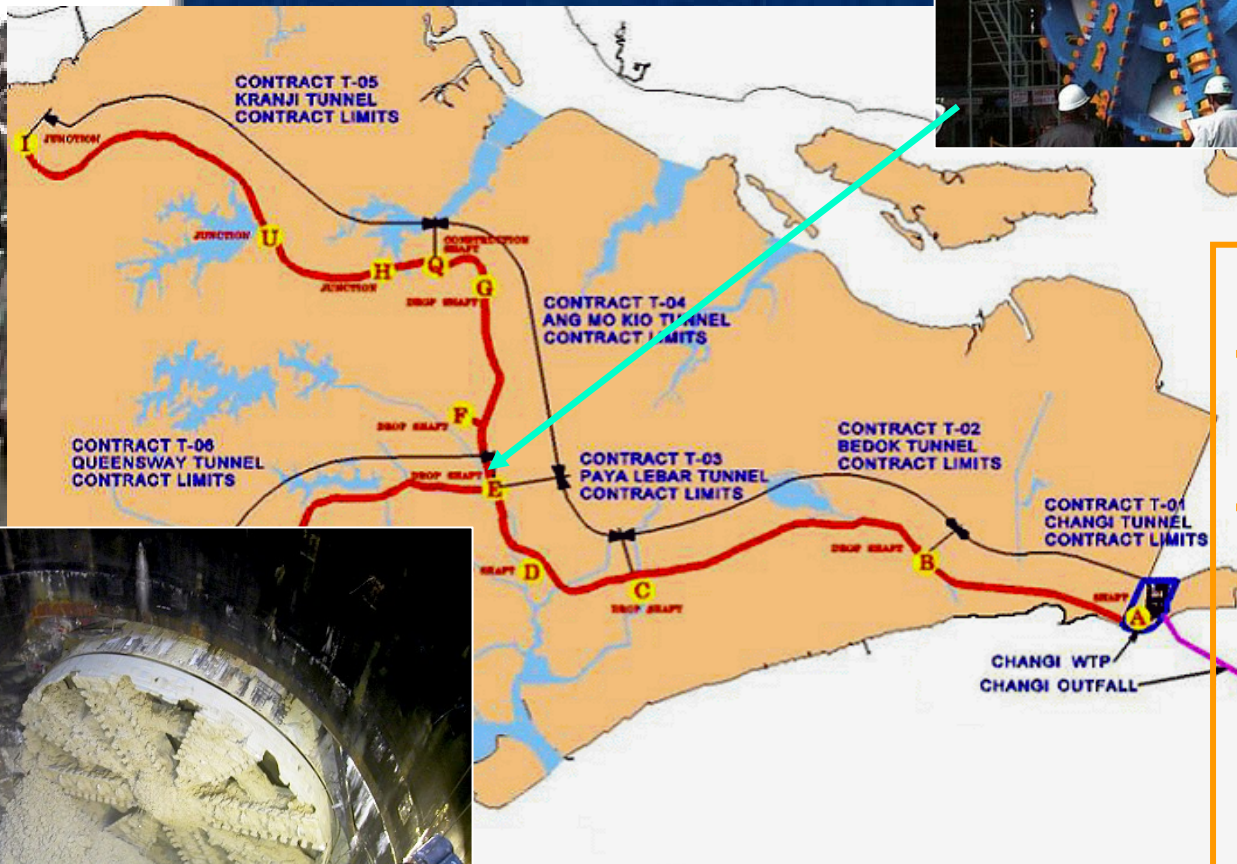
....Earth Pressure Balance TBM



Singapore Deep Tunnel – 7.2 m

... Singapore Deep Tunnel

Seven TBMs
Simultaneously 4.4 to 7.2 m



Contract T03
Tunnel Length
5150m (16900 ft)
TBM Diameter
7.2m (23.7 ft)
Record progress
In a month
536 m or 1658 ft



Commenced Tunneling Apr 01
Completed Tunneling Dec 02



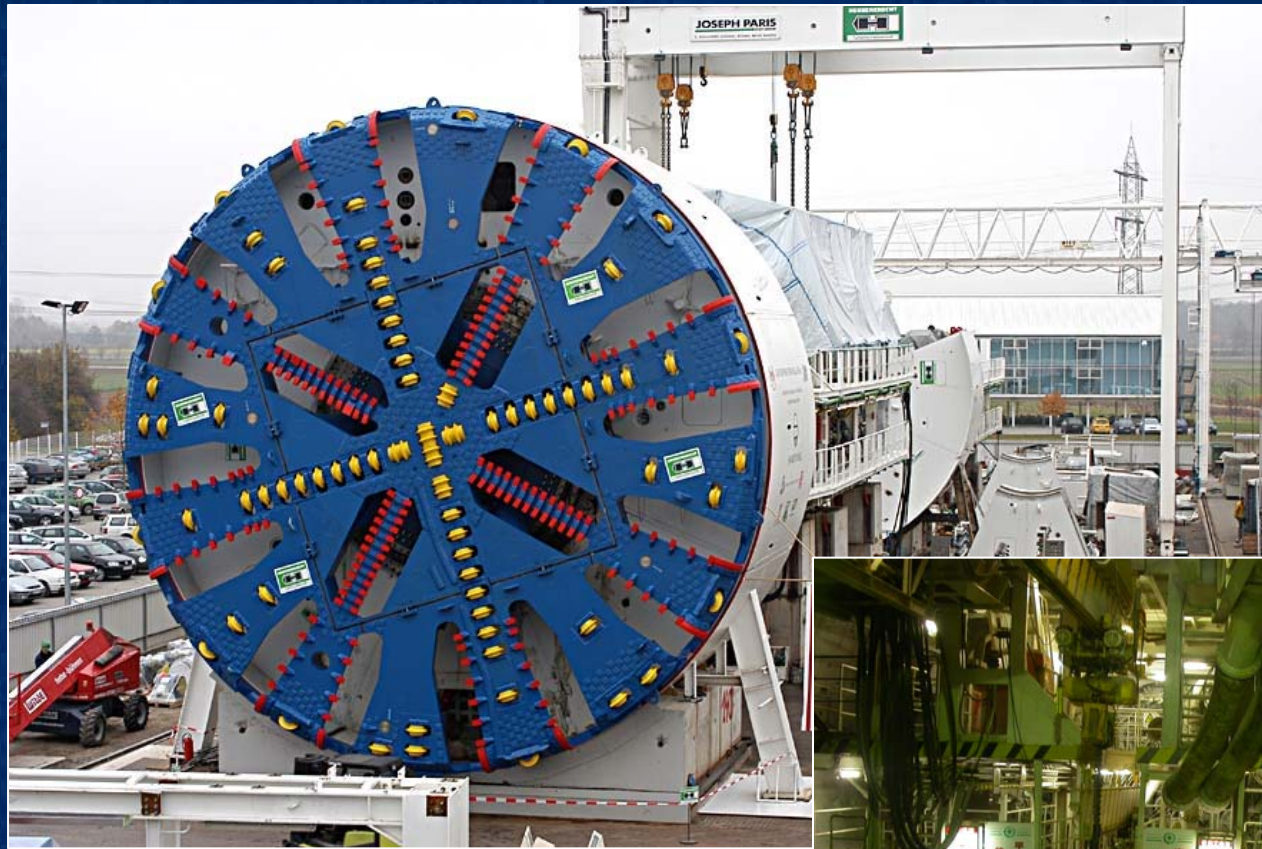
...EPB Binocular TBM



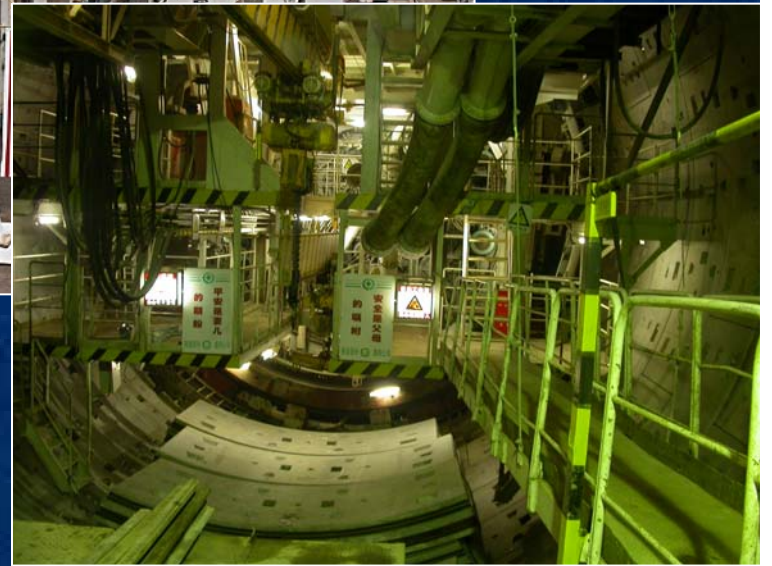
Shanghai Metro



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)



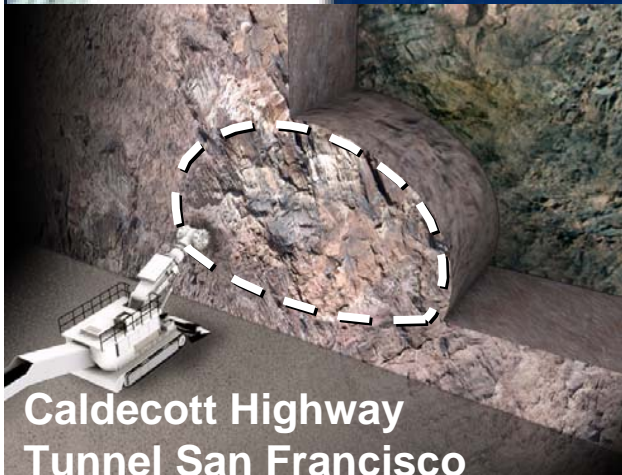
... Scenes from the Portland Westside CSO Project



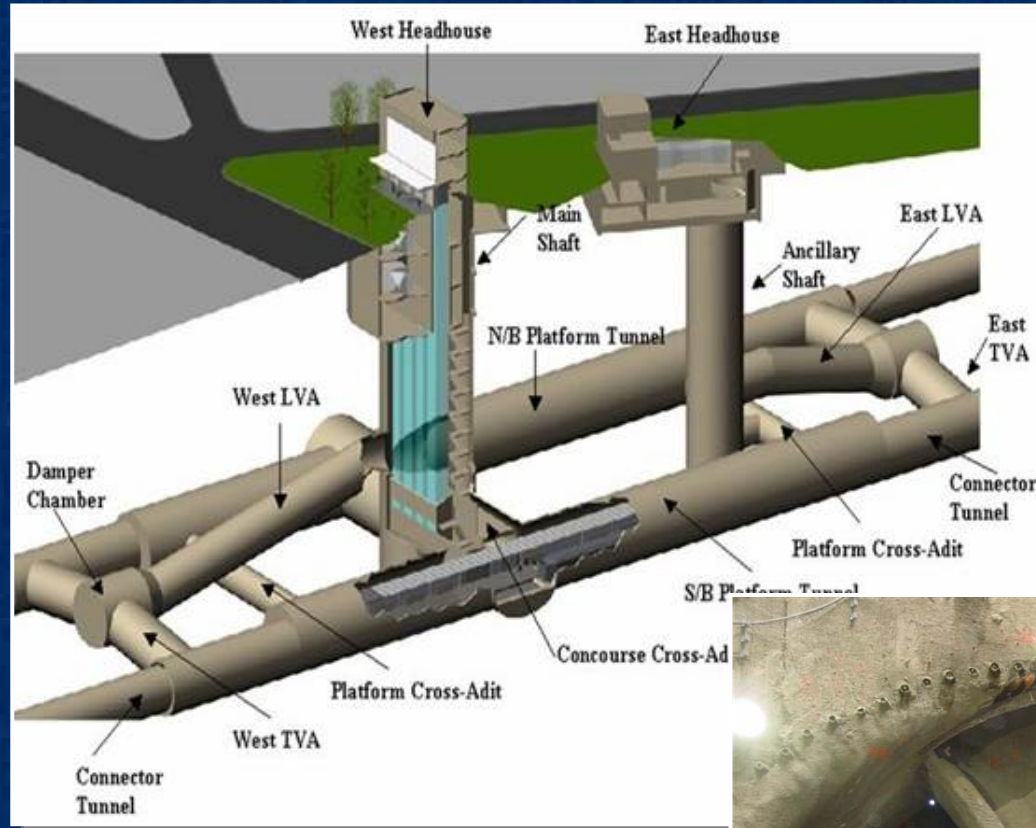
Tunnel Linings – State-of-the-Art in Precast Segments



New Austrian Tunneling Method



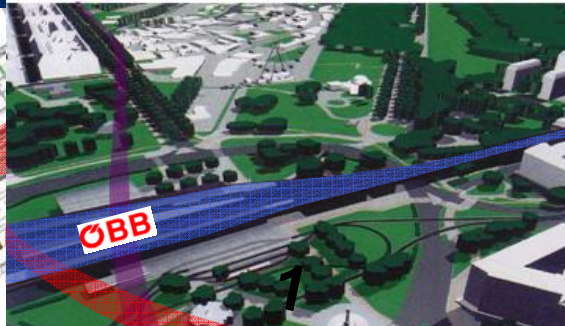
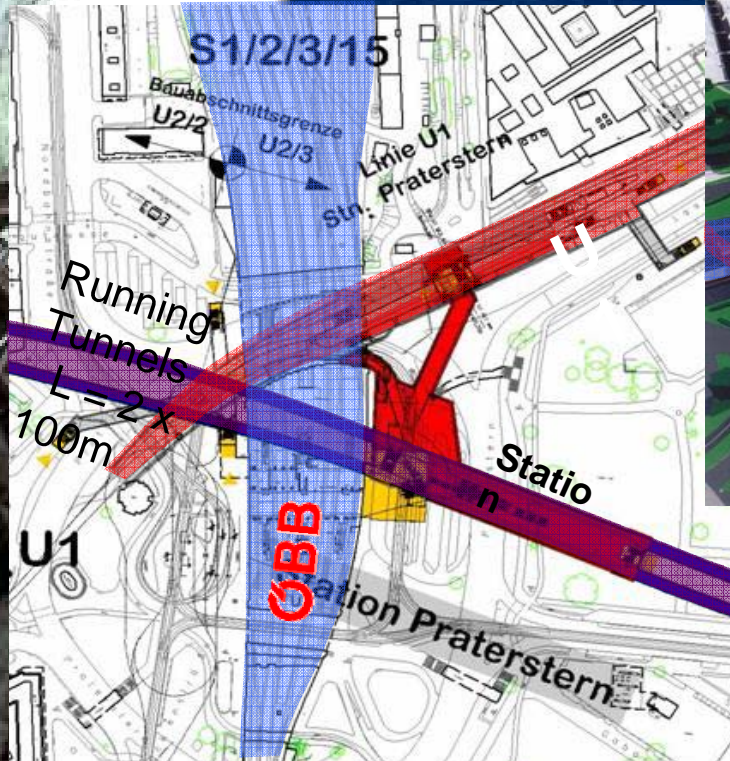
... NATM – Beacon Hill Station - Seattle



Beacon Hill Station - Seattle



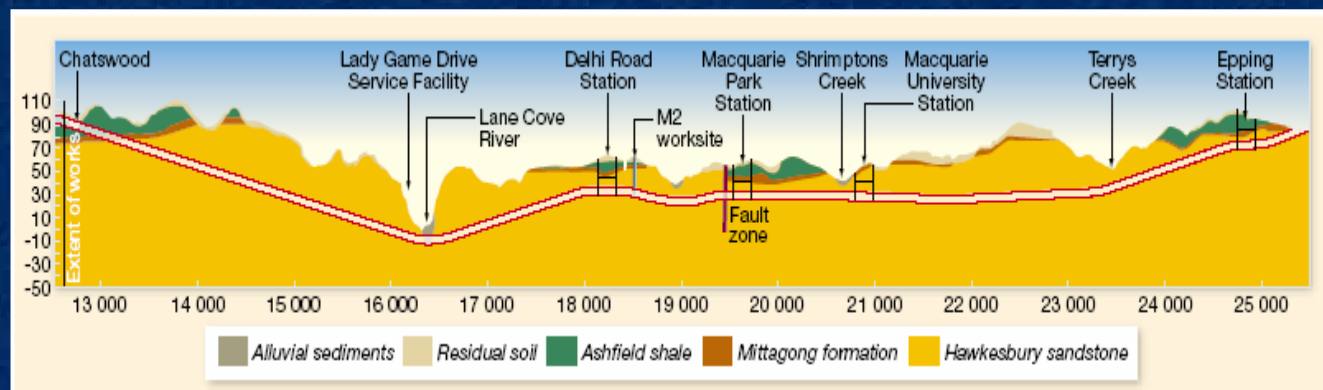
Vienna Metro Section U2/3



Pre-Support Measures



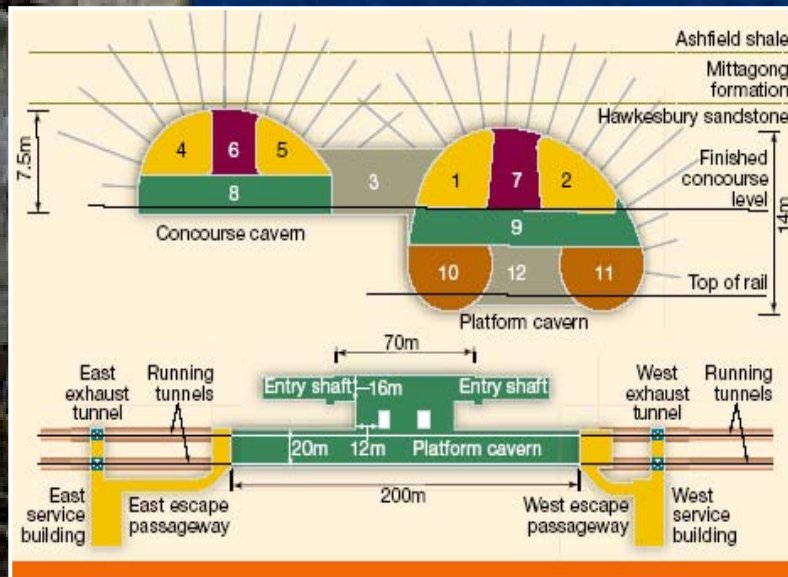
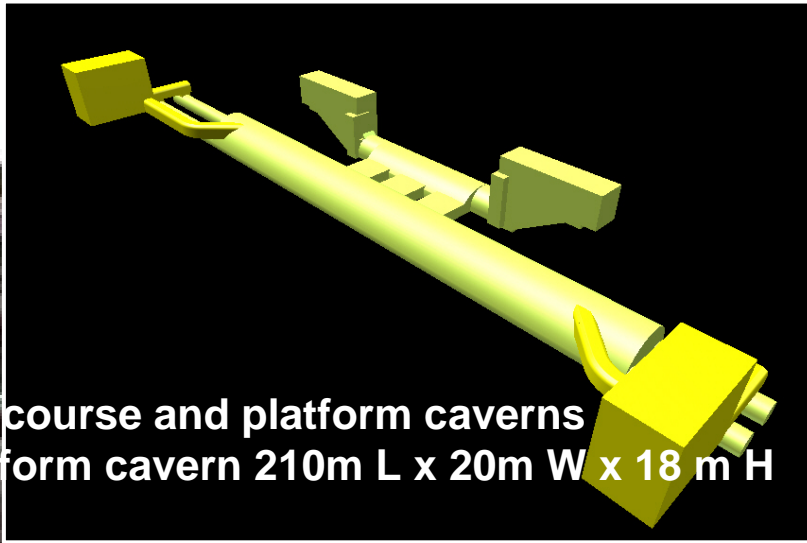
Cavern Construction



Parramatta Line - Sydney

... Macquarie Park Station

- 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

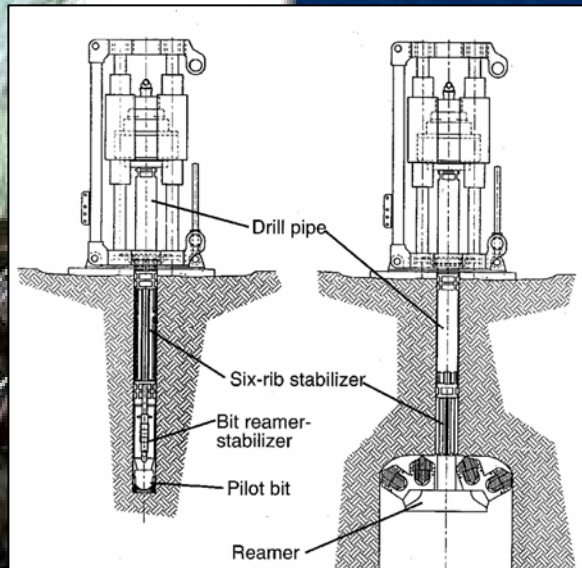


Slurry Wall Shaft

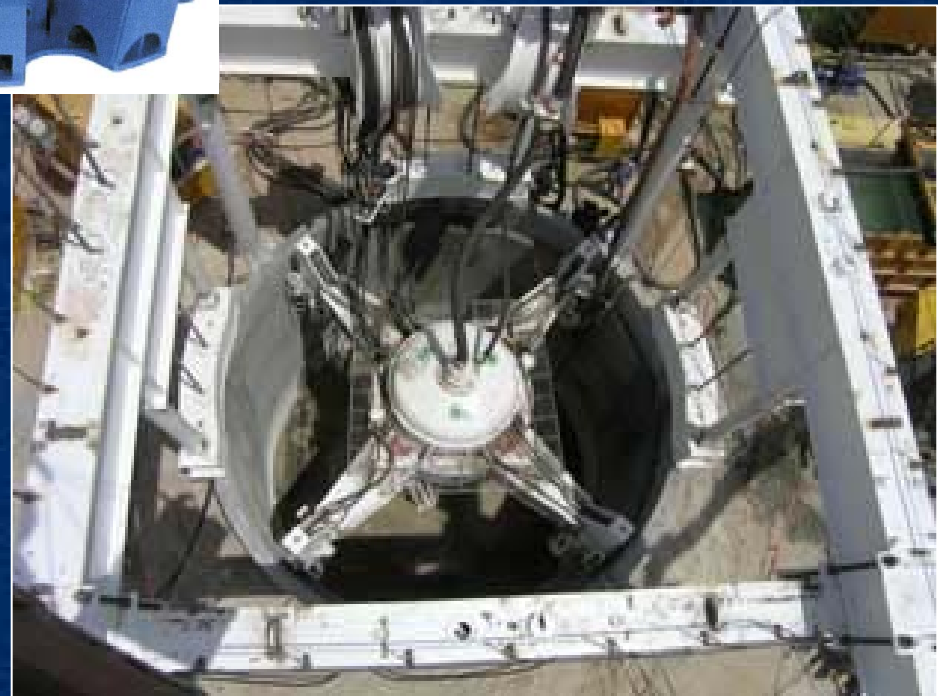


Secant Piles Shaft

...Shaft Construction

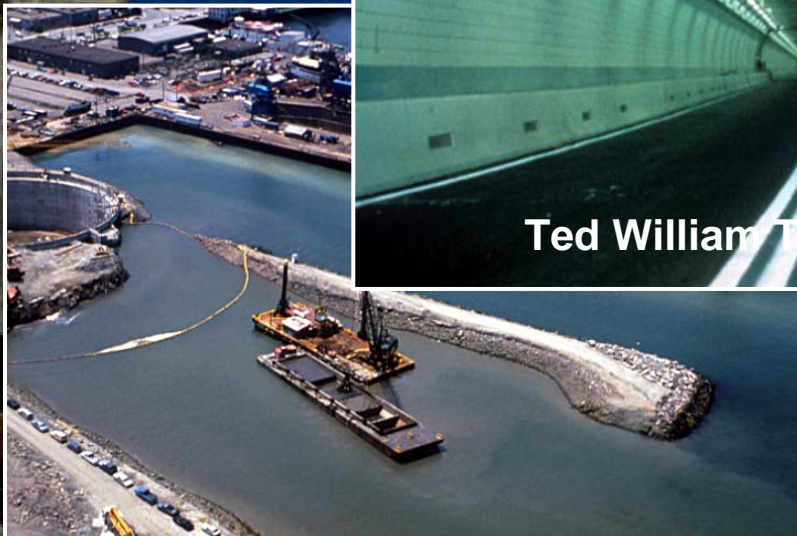
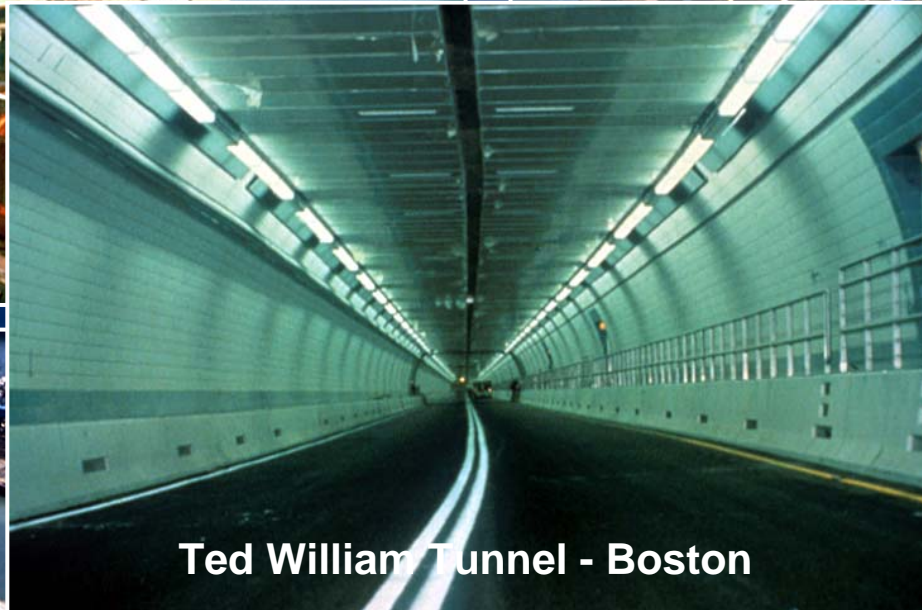
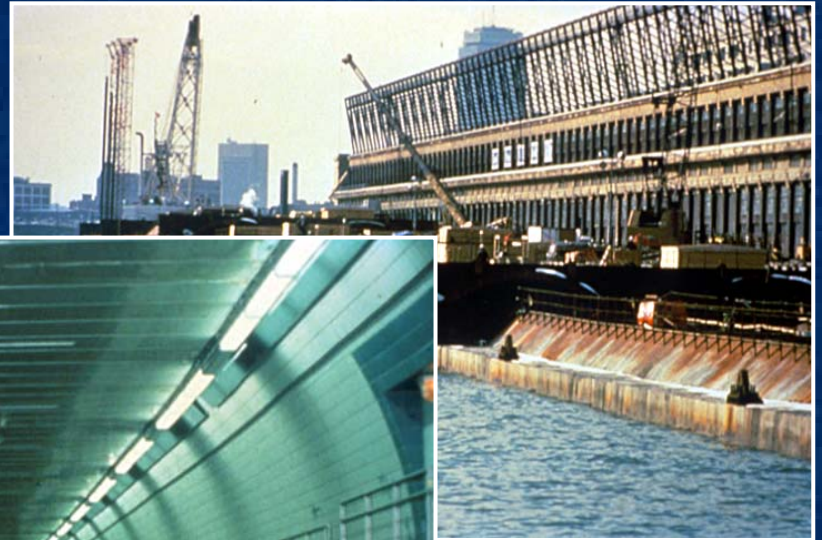


Raise-Bore



Segmental Shaft Boring Machine

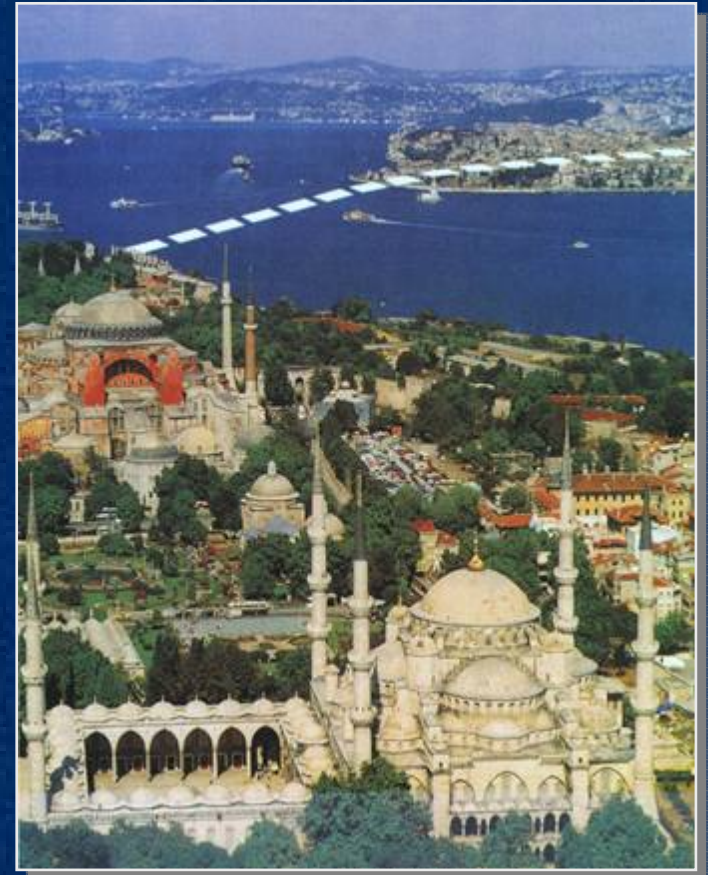
Immersed Tube Tunnels



...Immersed Tube Tunnels



Fort Point Channel Tunnel - Boston



Bosphorus Crossing



Tunnel Jacking




Central Artery Under South Station - Boston



Ground Improvement

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





Tunnel Systems

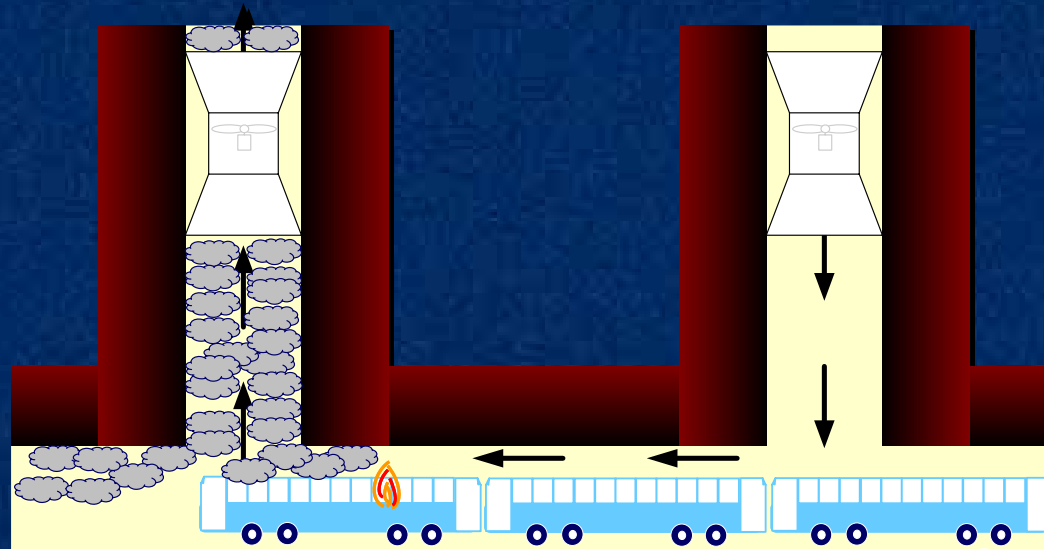
- Railroad Systems (tracks, signals, power, communications, Control, etc...)
- Highway Systems (traffic control, signs, power, communications, etc...)
- Tunnel Ventilation / Environmental Control Systems
- Tunnel Fire Life Safety
- Tunnel Lighting and Power
- Drainage
- Control Centers
- Safety and Security

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

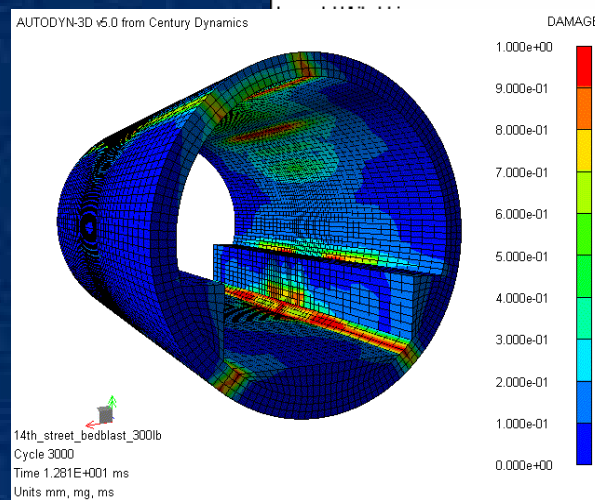
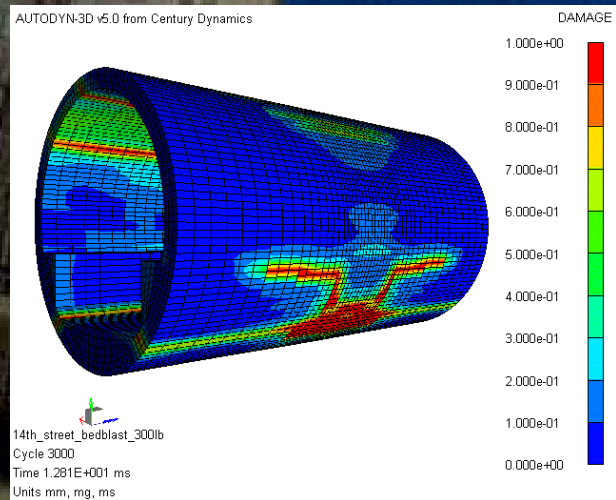
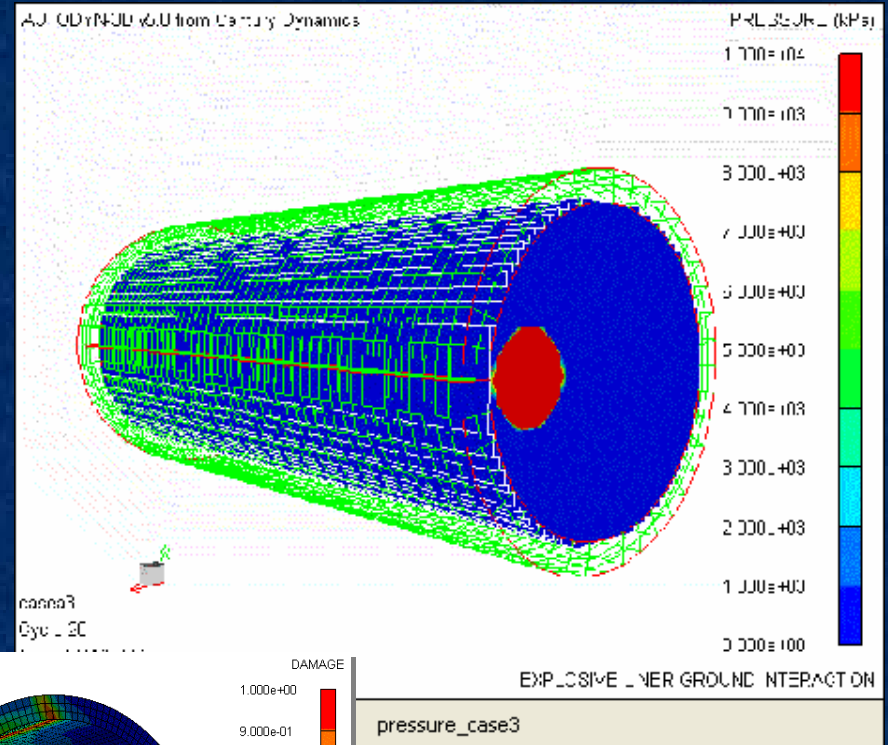
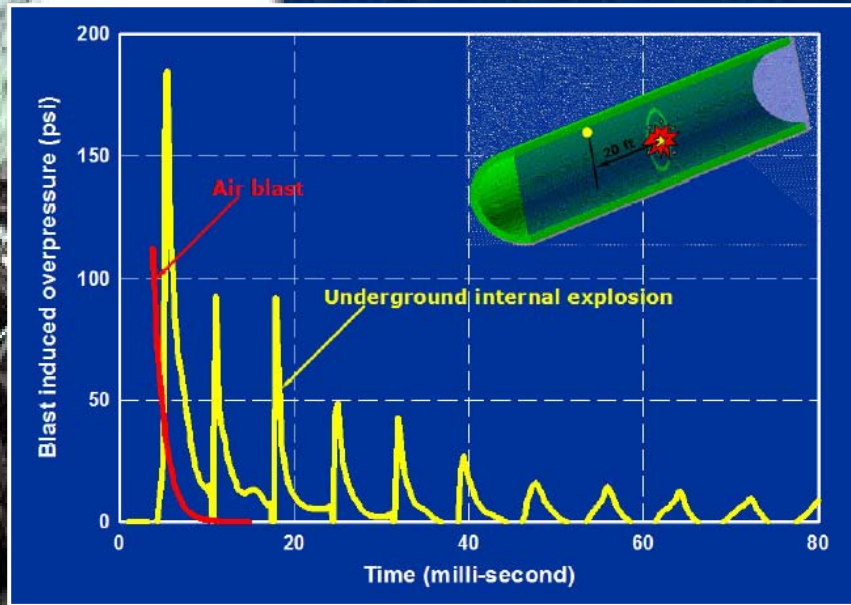


Station Exhaust



Platform Screen Doors

Design of Tunnels for Extreme Events

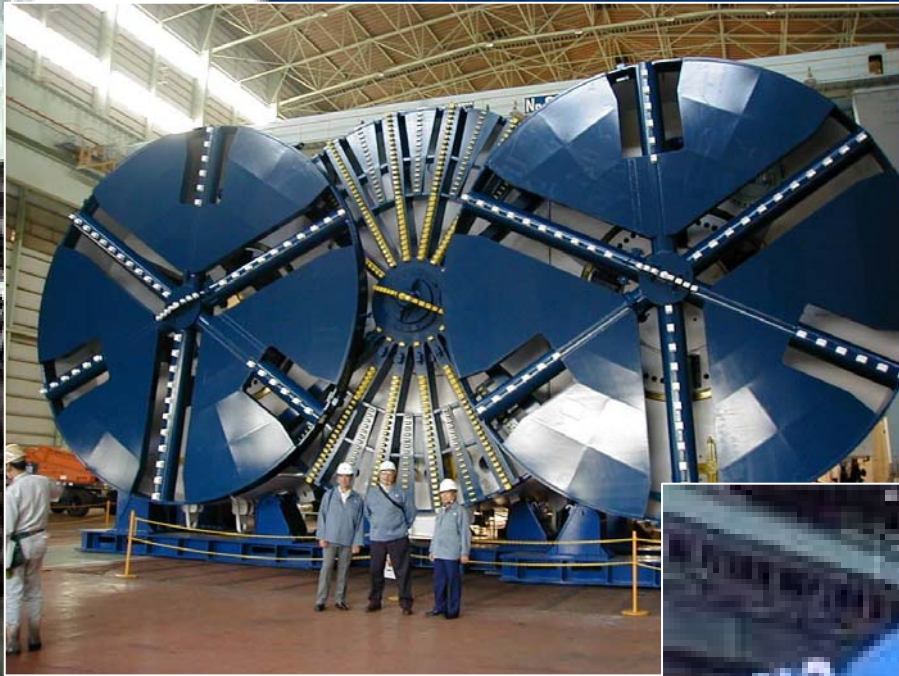


What's Next...



World's Largest TBM 15.2 m

What's Next....



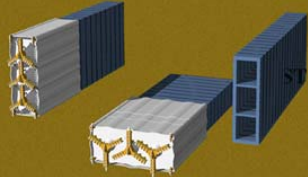
The Monster....



Multi Micro Shield (MMS)

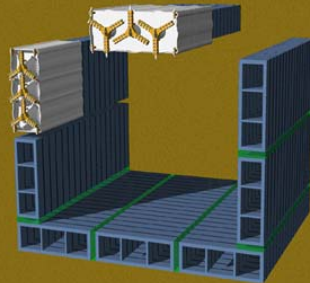
STEP 1

Construction of elemental tunnels using elemental shield machines



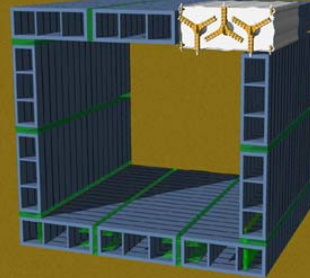
STEP 2

Connection of the elemental tunnels



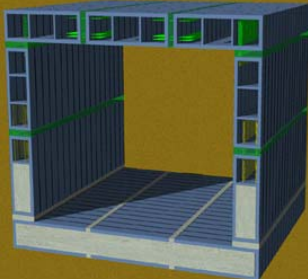
STEP 3

Placement of steel reinforcement in the elemental tunnels and connecting portions



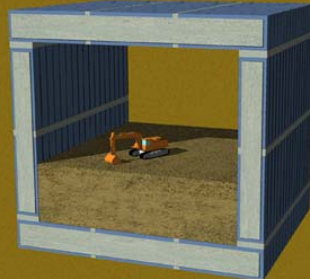
STEP 4

Placement of concrete
Construction of the entire MMST structure



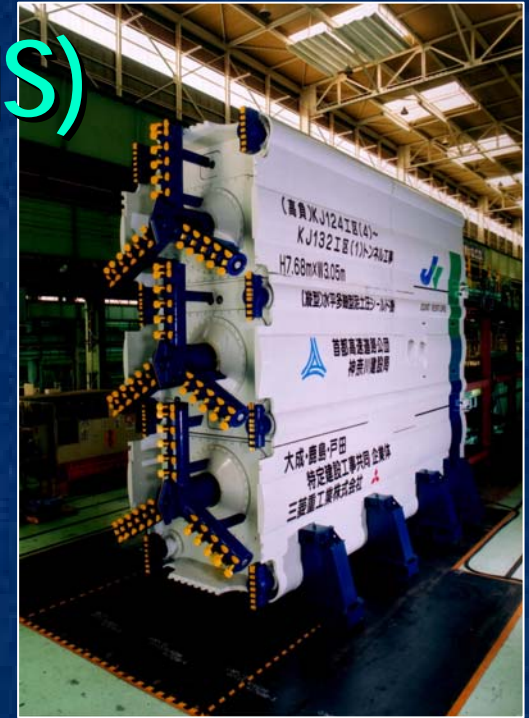
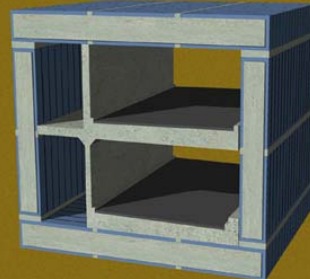
STEP 5

Excavation of soil from within the entire MMST structure



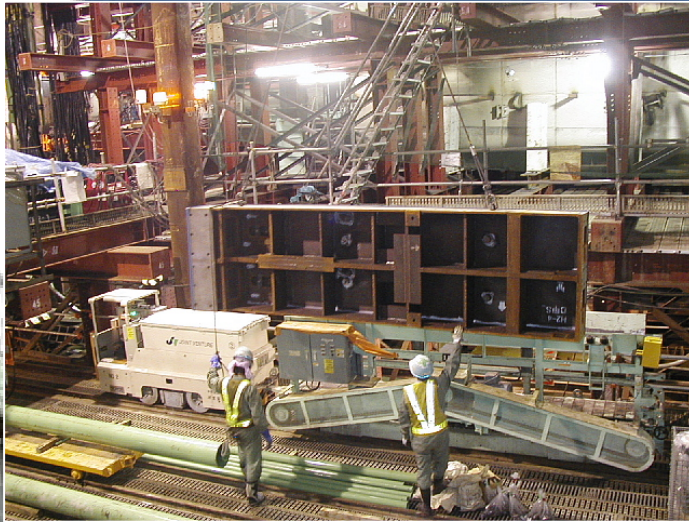
STEP 6

Construction of internals



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!