American Public Transportation Association

Review of Wilshire Corridor Tunneling

Los Angeles, California
October 24-27, 2005
Subway Scheme

Station

Running Tunnels

Station
# Solution Matrix for Subway in Contaminated Ground

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<th>Running Tunnels</th>
<th>Stations</th>
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<td><strong>During Construction</strong></td>
<td>Closed Face Tunneling (Slurry Technology)</td>
<td>Open Air Ventilation</td>
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<td><strong>During Operation</strong></td>
<td>Lining Designed to withstand Gases, even during an Earthquake</td>
<td>Double Walls with Ventilation and Monitoring</td>
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- **Closed Face Tunneling (Slurry Technology)**: Suitable for running tunnels to maintain a controlled environment during construction.
- **Open Air Ventilation**: Essential for stations to ensure safe and clean air circulation.
- **Lining Designed to withstand Gases, even during an Earthquake**: Ensures safety and durability during operation.
Tunneling in Los Angeles

Where We Are Now
TUNNELLING SCENE IS DOMINATED BY TWO TECHNOLOGIES

> Tunnel Boring Machines (TBM)

TBM with positive face control:
- Earth Pressure Balance (EPB),
- Bentonite Slurry (BS),
- and their various combinations (e.g. mix shield)

High Performance Hard Rock TBM

> Sequential Excavation Methods (SEM)

New Austrian Tunnelling Method (NATM)

Conventional Excavation Methods and their various modifications
EARTH PRESSURE BALANCE TBM and BENTONITE SLURRY TBM

> Originally developed for shallow, soft ground, urban tunnels to improve Ground Control and Surface Settlement

> These two technologies now completely dominate urban, shallow, soft ground tunnelling
Closed Face Techniques

Face support

Compressed air reservoir

Elastic spring element

Cut-off valve

Circulation pump

Input

Output

Compressor

Air pressure regulation

Slurry shield

Earth pressure balanced shield

Mixing bars

Slurry injection

Sandplug

Conveyor motor
Slurry TBM

- Compressed Air
- Airlock
- Mixshield
- Slurry Face Support
- Slurry Feed
- Slurry Discharge
Bentonite Slurry TBM Details
Slurry TBM Face Support

Face support with a bentonite suspension

Formation of a membrane (after Müller-Kirchenbauer)

Soil | Bentonite suspension
--- | ---
Membrane at the boundary surface | good stability
Stability by rheological blocking | no definite stability of individual grains
Formation of a membrane from coarse and fine particles | Limited stability
APTA Peer Review Debriefing for Los Angeles County Metro

Wilshire Corridor Tunneling Panel Review

Los Angeles, CA
October 27, 2005
Scope of Work

• “…conduct an independent evaluation and report on gas related safety issues associated with the proposed extension of the Red Line Subway along Wilshire Boulevard…

• …include both tunnel and station construction methods, and the long-term performance…

• … provide a conclusion as to whether tunnel and station construction and operation… can be implemented in a safe manner…”
What has changed since 1985?

• Attitude regarding safety has improved
• Instrumentation has improved
• Current TBM technologies have a good track record
• 20 years to learn the geology and address the problem
• Much more construction and operation experience in tunneling
• No problems with deep basements along Wilshire
General Recommendations

• Risk associated with H$_2$S is greater than methane. Therefore, alignment and station location should primarily consider H$_2$S risk.
• Alignment should minimize construction in the San Pedro (unsaturated) formation as much as possible.
General Recommendations (continued)

• Implement redundancy principles in safety design
• Implement owner controlled quality assurance program
• Stick to proven technologies
Is it Safe to Tunnel Along Wilshire? Findings

- Closed face slurry machines improve safety
- Experience with large diameter sewer tunnels in gassy ground has been positive
- Up-to-date information on gases is available
Is it Safe to Tunnel Along Wilshire?

**Recommendations**

- Stay with HDPE membrane and 2-pass system because it is a proven technology. Double gasket alternative must be proven from field experience.
- Alignment should minimize construction in the San Pedro (unsaturated) formation as much as possible.
- Be diligent in locating abandoned wells.
- We are aware of two case studies of tunnels that were abandoned because of inflows of water and \( \text{H}_2\text{S} \). The MTA design team should review these case histories for lessons learned. Check for others.
Is it Safe to Construct Stations Along Wilshire?

Findings

- Deep basements have been constructed safely along Wilshire, some in tar sands
- Stations along Wilshire alignment can be sited to minimize intrusion into the San Pedro and exposure to gas problems
- Technology of retaining walls for cut and cover construction has improved
Is it Safe to Construct Stations Along Wilshire?

Recommendations

• Use a trial pit constructed in tar sand areas to measure earth pressure and gas pressure

• Locate stations to minimize exposure to tar sands and highest gas concentrations
Is it Safe to Operate Along Wilshire?

Findings

• Gas monitoring is effective
• Gas monitoring using state-of-the-art instrumentation is being implemented by MTA which has procedures to upgrade instrumentation
• Ventilation system can be designed to clear the expected levels of gases
Bottom Line

It is possible to tunnel and operate a subway along the Wilshire Corridor safely. By following proper procedures and using appropriate technologies the risk would be no greater than other subway systems in the US.