A New Era of Tunnel Blasting: Electronic Detonators and Geohazard Reduction

Geohazards in Transportation
August 3, 2005

Doug Anderson
Senior Supervising Geologist
Senior Professional Associate
Parsons Brinckerhoff
Overview

- Issues in Tunneling
  - Vibration
  - Wall Damage/Overbreak
- Example Tunneling Projects (Urban)
- Traditional Blasting Approach
  - Overall Procedures
  - Vibration Generation
- Electronic Detonator Fundamentals
- Application to Tunneling
- Implications
Before We Begin…

- Presentation is Informational
- NOT a Sales Pitch
  - PB does not manufacture or sell electronic detonators
  - Strictly to promote advances in the state-of-the-art
Geohazard Issues in Tunneling

For the Client
- Stability of the Project
- Safety and Security

For the Stakeholders
- Protection of Neighboring Assets
  - Stability of Underground Structure
  - Vibration
Example Tunneling Projects

- Two New York City Projects
  - Hard Rock (Manhattan Schist)
  - Close Proximity
    - High-Value Surface Structures
    - Network of other Tunnels, Underground Structures
- East Side Access
- Number 7 Line Extension
East Side Access

New LIRR Tunnels

LIRR Terminal in GCT Lower Level

GRAND CENTRAL TERMINAL
East Side Access
East Side Access

- Tunnel Boring Machine for Long Drive

- Blasting for:
  - Station Cavern
  - Shafts and Adits
    - Access Shafts
    - Vent Shafts
  - Cross Passages
East Side Access

- **Client**
  - Long Island Railroad

- **Stakeholders**
  - Metro North Railroad
    - Grand Central Terminal
    - Overlying Rail Lines
  - New York City Transit
    - Adjacent Subways
  - Historical and Expensive Surface Structures
Number 7 Line Extension

- Tunnel Boring Machine for Long Drive

- Blasting for:
  - Station Caverns
  - Shafts and Adits
  - Cross Passages
Number 7 Line Extension

- **Client**
  - New York City Transit

- **Stakeholders**
  - Port Authority
    - Bus Terminal
    - Lincoln Tunnel
  - Amtrak
    - Hudson River and Empire Line Tunnels
  - Long Island Railroad
    - Adjacent Yards
  - Surface Structures
    - Javits Convention Center
    - Historical Structures
Geohazard Issues Revisited

- **Client**
  - Design Issues KNOWN
    - Overbreak and Stability
    - Vibration Predictable and Controllable

- **Stakeholders**
  - Confidence:
    - Structure will be Stable
    - Vibrations will be Minimal

- **Overall – NO Surprises**
Electronic Detonators
And the Issues

- Vibrations Predictable and Controllable
- Overbreak Reduced

- Electronic Detonators Mandated
  - Why? I’ll Tell You
Traditional Blasting Approach

- Timed Sequence of Specialized Blastholes
  - Burn Cut
  - Production Holes
  - Perimeter Holes
- Long Period Delays
Traditional Blasting Approach

- Long Period Delays
- Several Holes on one delay
- Scatter assumed “good”
Problems with Traditional Approach

- Burn Cut irregularly developed
- Production Holes Inefficient
- Perimeter Holes Irregular – Overbreak

- Vibration Unpredictable

- Overall: Non-reproducible Results
Detonator Comparison

- Similar Size for both
- Pyrotechnic:
  - Delay Element is Train of Explosive
  - Delay time related to length and density of explosive
- Electronic:
  - Delay Element is Computer Chip
Electronic Detonator Advantages

- **Accuracy of Firing Times (scatter)**
  - Electronic: 0.5 ms Irrespective of Period
  - Pyrotechnic: 2% of firing time
    - For 1500 ms Long Period Delay = 30 ms

- **Safety**
  - Circuits Checkable Before and After Blast

- **Security**
  - Detonator Fired by Specific Blasting Machine
Example

Courtesy Claude Cunningham

- The perimeter control and the over break experienced using shock-tube timing. With E-Det timing the half barrels on the perimeter are clearly visible as well as the minimal over-break experienced.

- The damage to wire meshing and roof bolts is extensive with shock-tube. Resulting in the mine having to re-support each blast using this system at great expense. When using E-Det timing little if any damage is experienced.

Joao Campos & AEL team: El Teniente, 2000
Japanese Study (1995)*
Comparing Electronic and Pyrotechnic

- Electronic Used Only on Perimeter Holes
- Cracking and Seismic Profiling Measured

* Yamamoto, Ichijo, and Tanaka, ISEE Proceedings
Japanese Study (continued)

- Pyrotechnic Delays Produced 1 meter of Damaged Rock
- Reflected in Both Overbreak and Subsurface Damage
Japanese Study (continued)

- Damage Restricted to 0.1 meter Below Surface
- Less Overbreak and Damage

V1 = 1780 m/s
V2 = 6070 m/s
Application of Electronic Detonators to Tunneling

1. Applied to Standard Delay Sequence – Long Period
2. Shorter Delays Possible!

Perimeter Holes
Production Holes
Burn Cut
Why a “New Era”? 

- Effects Design by Accurate Knowledge of Blast Effects 
- Possible Redesign with Shorter Delays 
  - More Effective Use of Explosive Energy 
  - Vibration Control Methods by Superposition Possible
Implications for Geohazards

- Important in Urban Environments
  - Stability and Vibration Control

- Stability ALWAYS an Issue

- Vibration Control Increasingly Important – even in the “Hollers”
THANK YOU!!!!