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

Geohazards in Transportation

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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

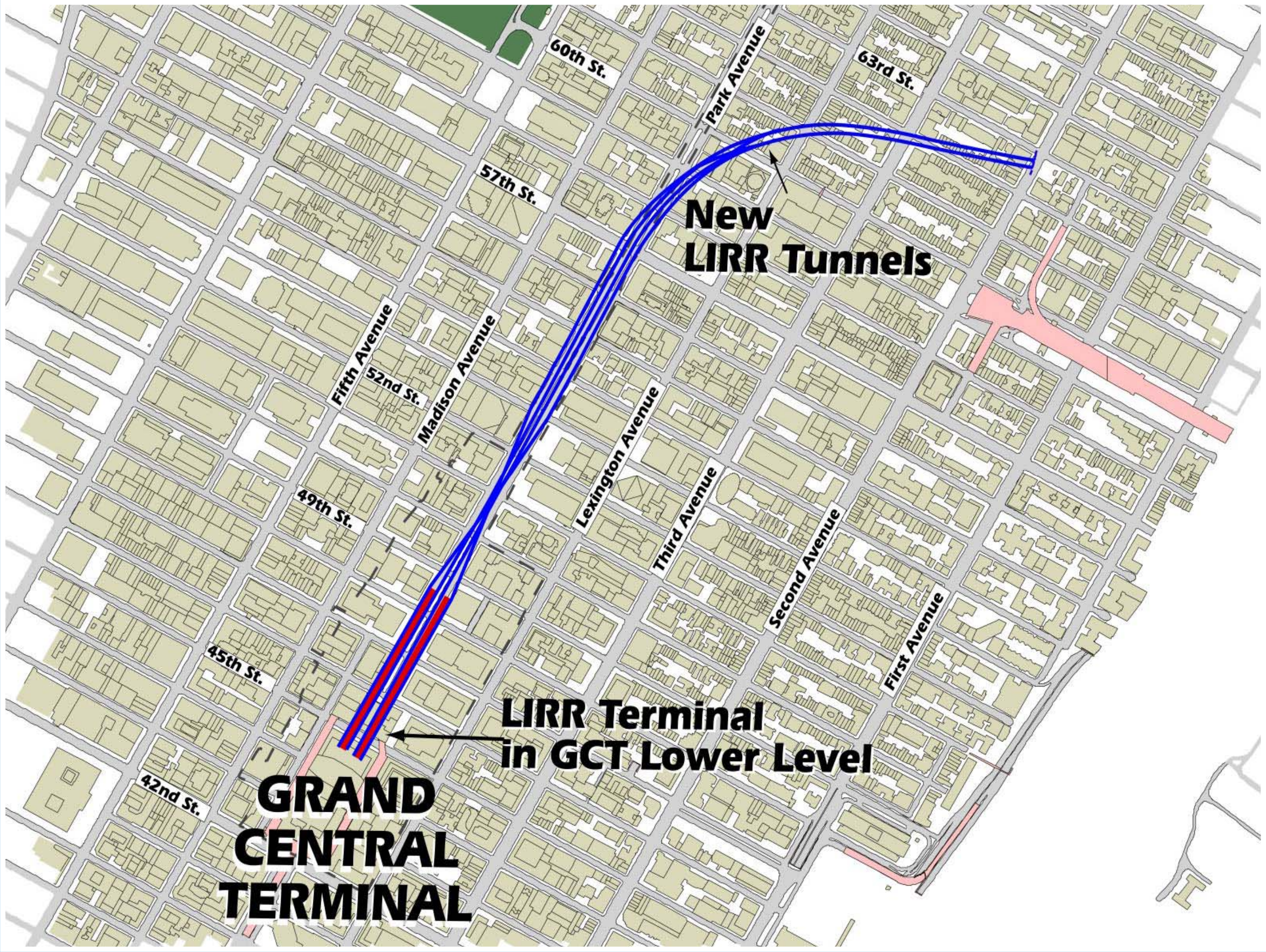
- For the Client
  - Stability of the Project
  - Safety and Security

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

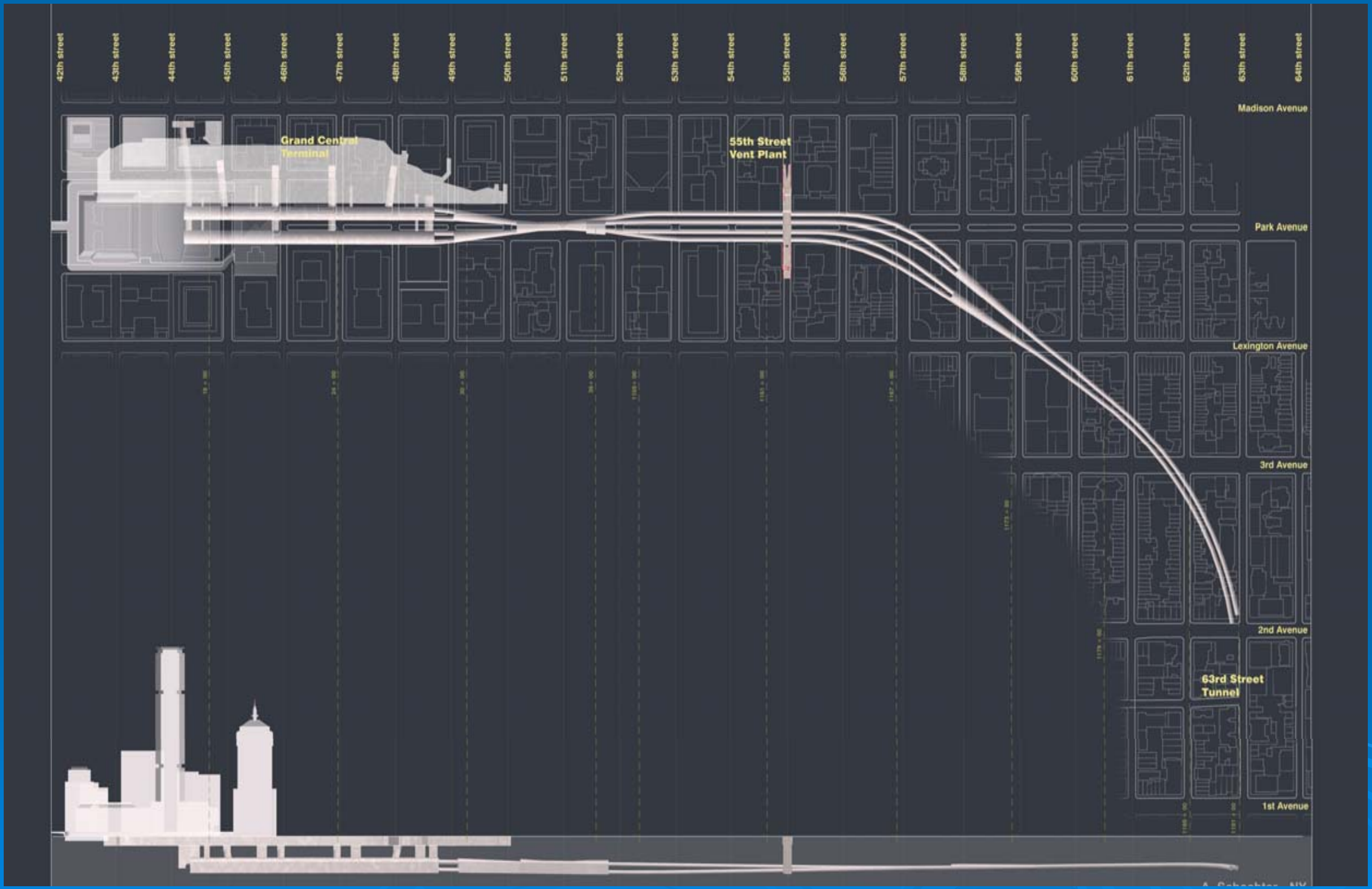
Example Tunneling Projects

- 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



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

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

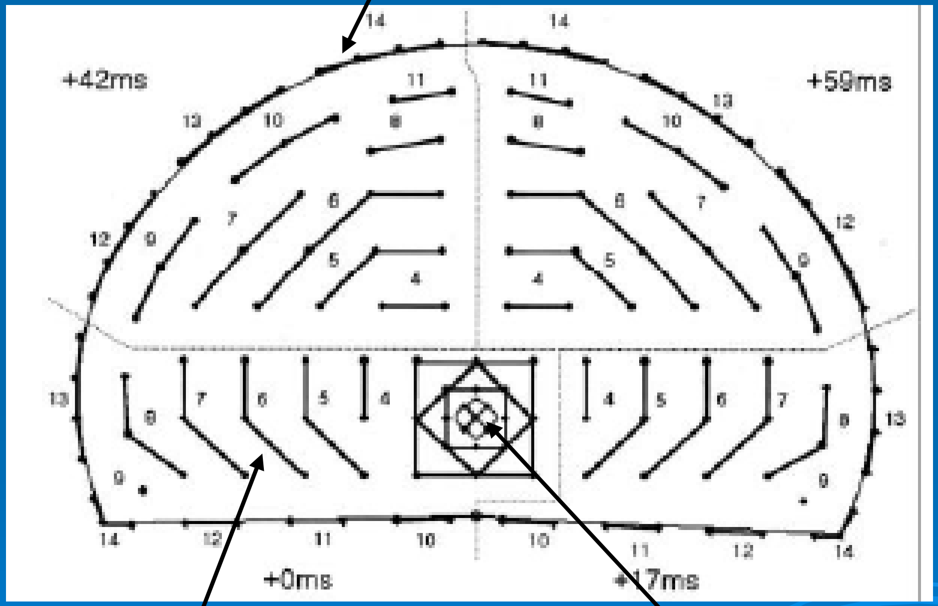
Traditional Blasting Approach

- 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”

Perimeter Holes



Production Holes

Burn Cut

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

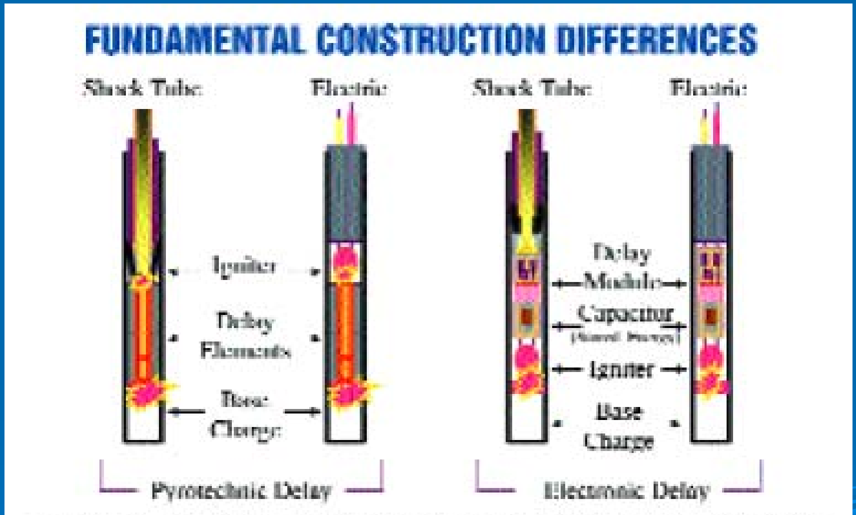


Figure 1 - Fundamental Construction Differences © IME 2002

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

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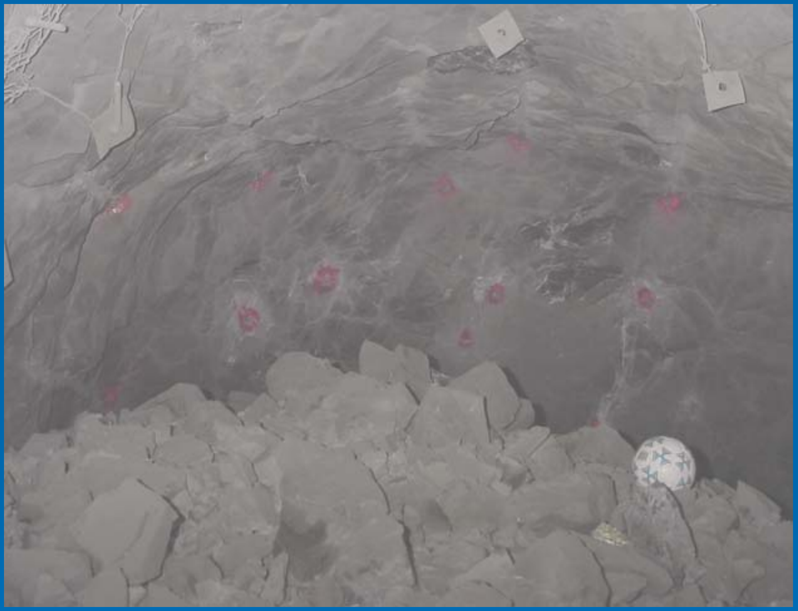
Example
Courtesy Claude Cunningham

- 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.

Electronic perimeter



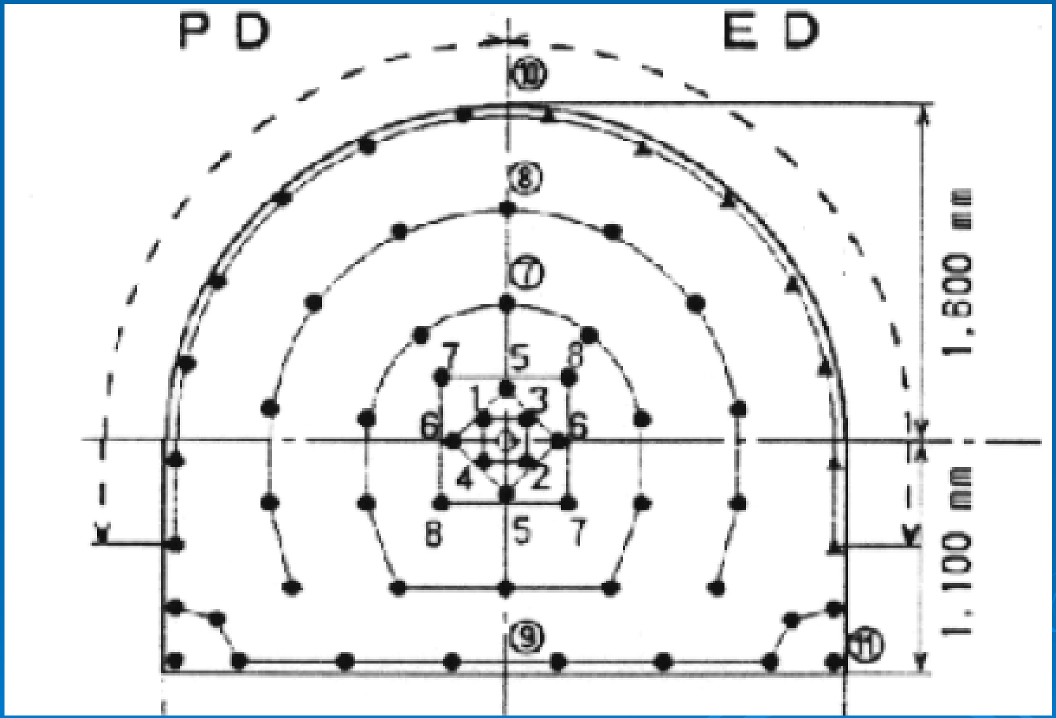
Shocktube perimeter

- 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

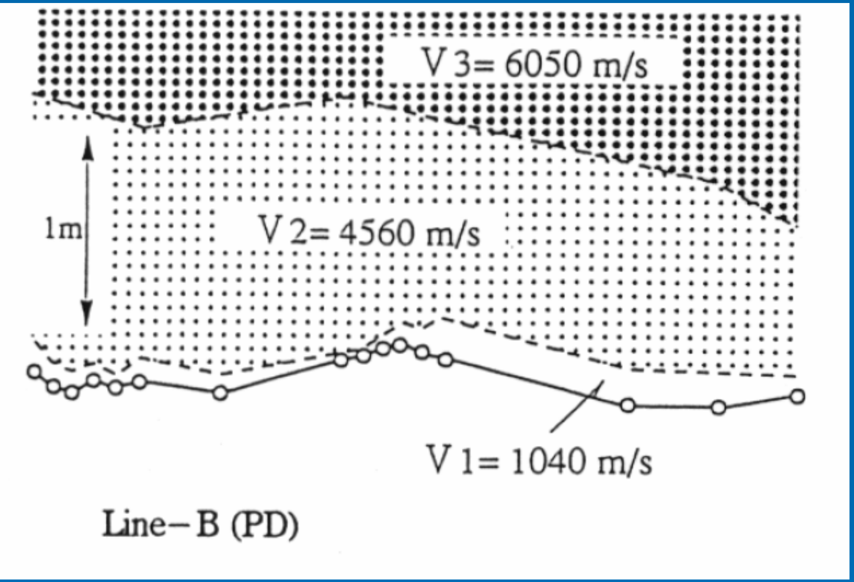
- Electronic Used Only on Perimeter Holes
- Cracking and Seismic Profiling Measured



* Yamamoto, Ichijo, and Tanaka, ISEE Proceedings

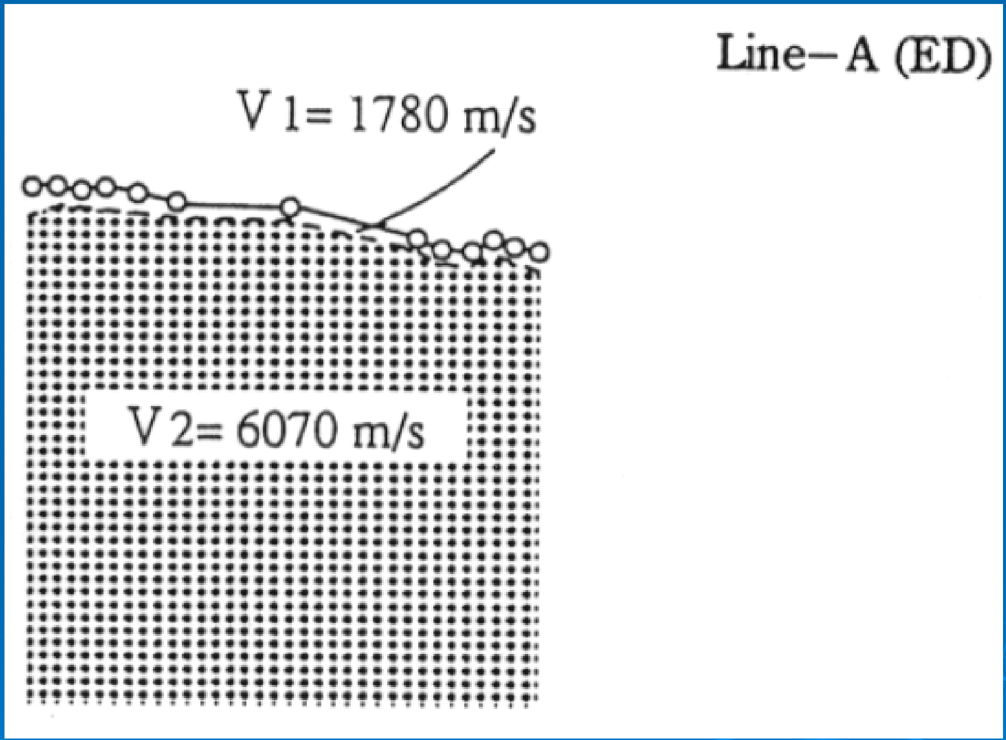
Japanese Study (continued)

- Pyrotechnic Delays Produced 1 meter of Damaged Rock
- Reflected in Both Overbreak and Subsurface Damage



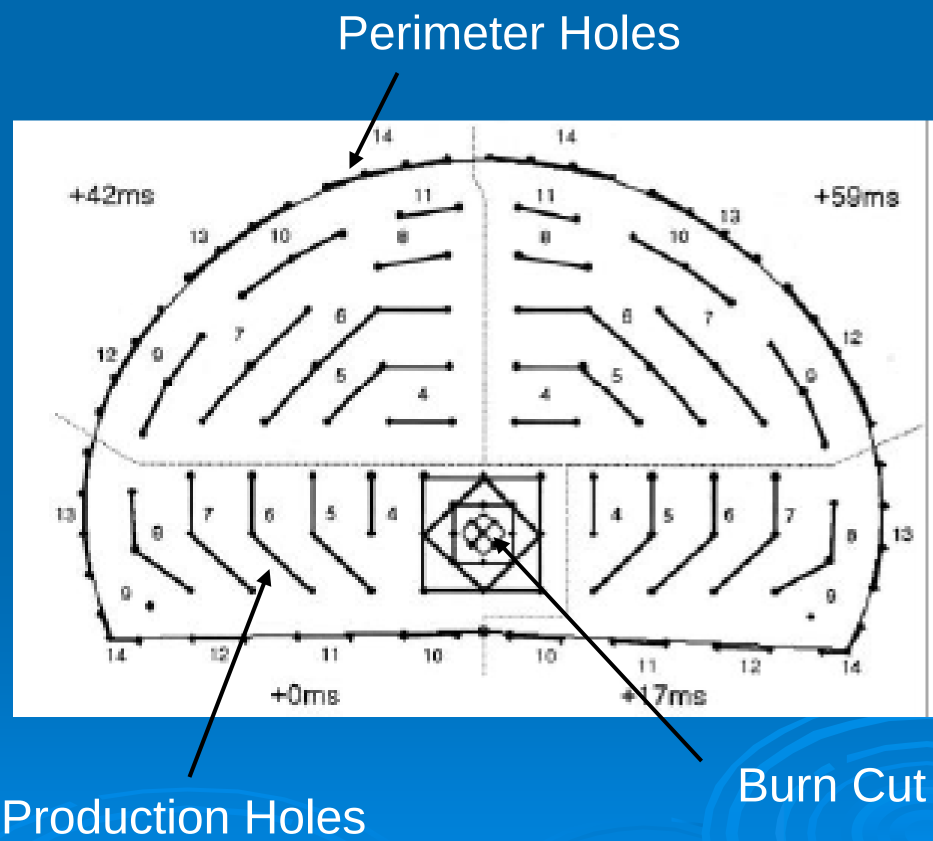
Japanese Study (continued)

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



Application of Electronic Detonators to Tunneling

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



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

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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!!!!