ALASKAN WAY TUNNEL ISSUES

Management & Technical Considerations, for Major, Complex Tunnel Projects

From Presentations: WSDOT Commission 2004
plus other Agencies and Groups World-Wide

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  - Previously Chair of USNCTT & UTRC & Shotcrete ACI-506
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  - Past President, American Underground Construction Assoc.
  - Previously Animateur, ITA Working Groups 13 & 20.
- Don Phelps
  - Vice President, Hatch Mott MacDonald
  - Past Vice President, Tunnelling Association of Canada
  - Previously Canadian Delegate to International Tunnelling Association

Many presentations on these issues

- Presentations and worksessions in many countries
  - Vienna, Basel, Melbourne, New York, Oslo, Frankfurt, Mexico City, Seattle, Beijing, Milan, Ferrara, Bern, St. Petersberg, Vancouver, Durban, Lisbon, Boston, Salzburg, Sydney, Amsterdam, Singapore, Istanbul, Beijing, Prague, Acapulco, Seoul, Singapore, Toronto, Madrid, Washington DC, New York, Prague, Cairo, New Delhi, Hanoi, Sao Paulo, Stockholm

- Resulting in input, presentations & discussion (examples):
  - ASCE Geotechnical Symposia; New York, 1999; Seattle, 2006
  - Beijing Symposia - TBM implementation 2000, 2001, 2005 (1st phase of the South-to-North water transfer scheme – 260km tunnels)
  - American Underground Construction Association, 2000-2002
  - Swedish Rock Committee & Swedish Road Authority - 2001
  - ITA Working Groups 13 & 20, 1997-2004
  - Washington Department of Transportation Commission, 2004
  - Port Authority of NY & NJ, 2007
  - Gibraltar Tunnel TBM Workshop, 2005
  - TBM Workshop, New Delhi, 2004

Tradtional reasons for going underground

- Location and land use pressures
- Environmental preservation
- Improved Sustainable Development
- Energy conservation
- Topography / crossings
- Physical isolation
  - Resistance to weather and storms
  - Resistance to earthquakes

Above-ground structures are more sensitive to earthquake than underground ones
Kobe Earthquake (Japan - 1995)

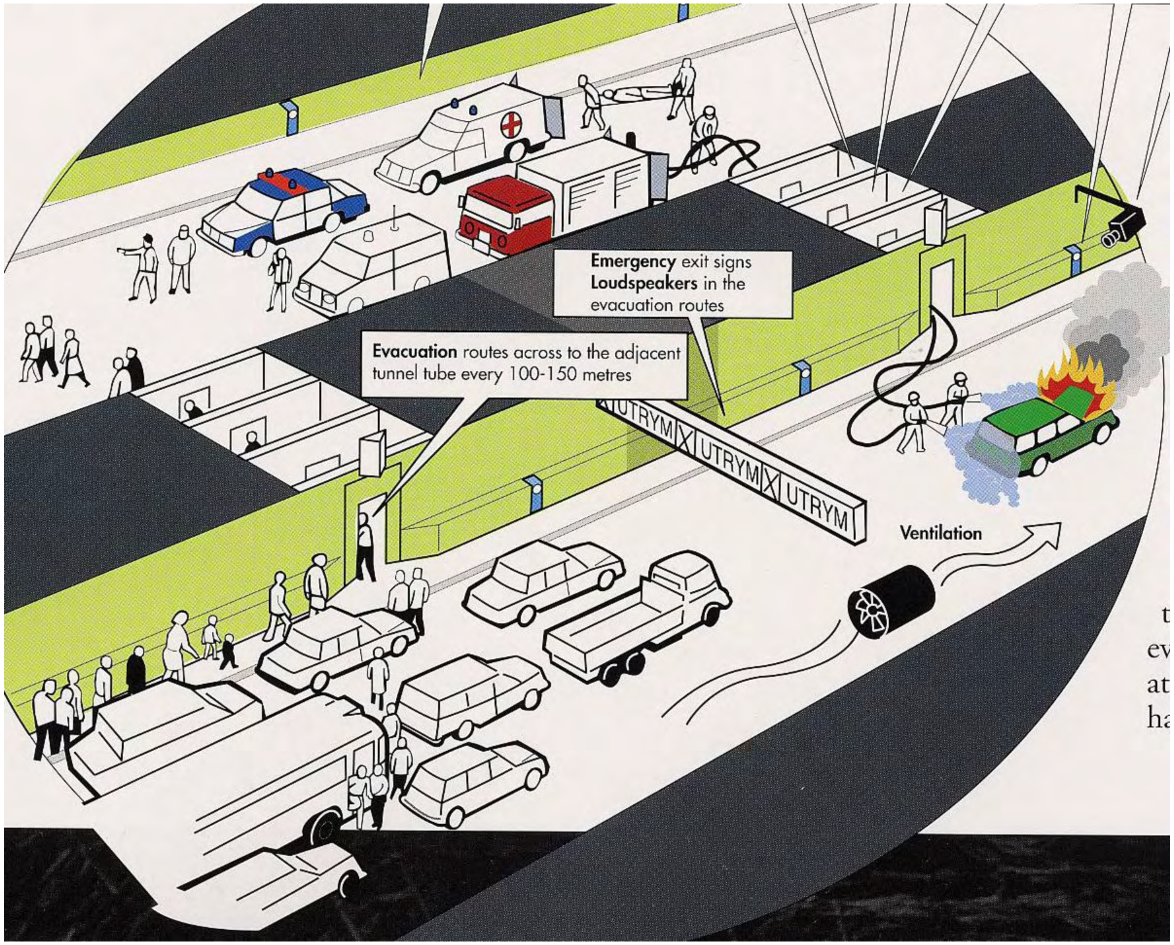
Severe damage to the Kobe City Hall

No damage to the underground shopping mall located below

Source ITA

Tunnels include Multiple Safety Systems

- Fire-Life Safety (suppression)
- Ventilation
- Lighting & Signage
- Communications
- Surveillance
- Management plan
- New Developments
  - NFPA 502
  - EU Directive



Tunnel Concepts for Alaskan Way

- Difficult but Technically Feasible
  - Twin 43 ft Diameter Tunnels
  - Single 54 ft Diameter Tunnel
- Provide Value to Community & Industry
  - Values that are Unique to the Tunnel Concept
- Expensive
  - Initial Capital Cost Exceeds Available Funds
  - Tunnel would be More Competitive if Consider:
    - Financial Value of Environmental Benefits
    - Life-Cycle Benefits & Costs
    - But No Mechanism to Consider these Issues Directly

Un-quantified Life Cycle Costs & Benefits

- Most underground facilities last much longer than surface counterparts
  - Implies lower life cycle cost

- Must take into account all aspects of cost over the service life of project
  - Must account for operational costs such as ventilation, etc.
  - Must account for indirect costs & benefits

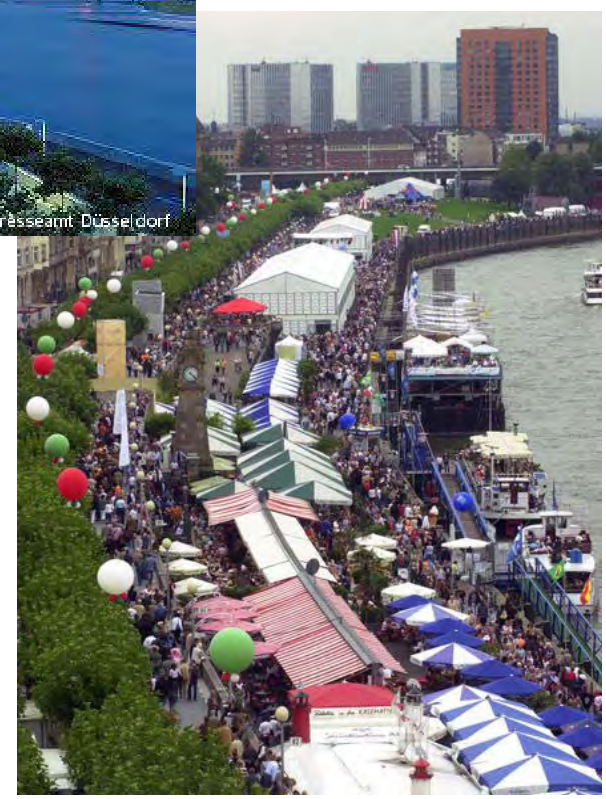
Include Equivalent Financial Value of Environmental Benefit

- Value of:
  - Less pollution
  - Less noise
  - Energy Savings
  - Lack of Visual Detraction
  - Improved Value of Overlying Surface & Facilities
- Value of Use of Land for More Noble Purposes
  - Use as a park or other civic gathering area
  - Such as Forest Preserve

Many Reasons for an Alaskan Way Tunnel

- Opens Waterfront for the Community
  - Without sacrificing traffic & transfer of goods
- Minimizes congestion on City Streets
- Bypasses Battery Street Tunnel
  - Improved Safety & Throughput Capacity
- Minimizes Disruption to Public & Businesses
  - During Construction & in Service
- More flexible routing/location
- Life-cycle & Environmental benefits

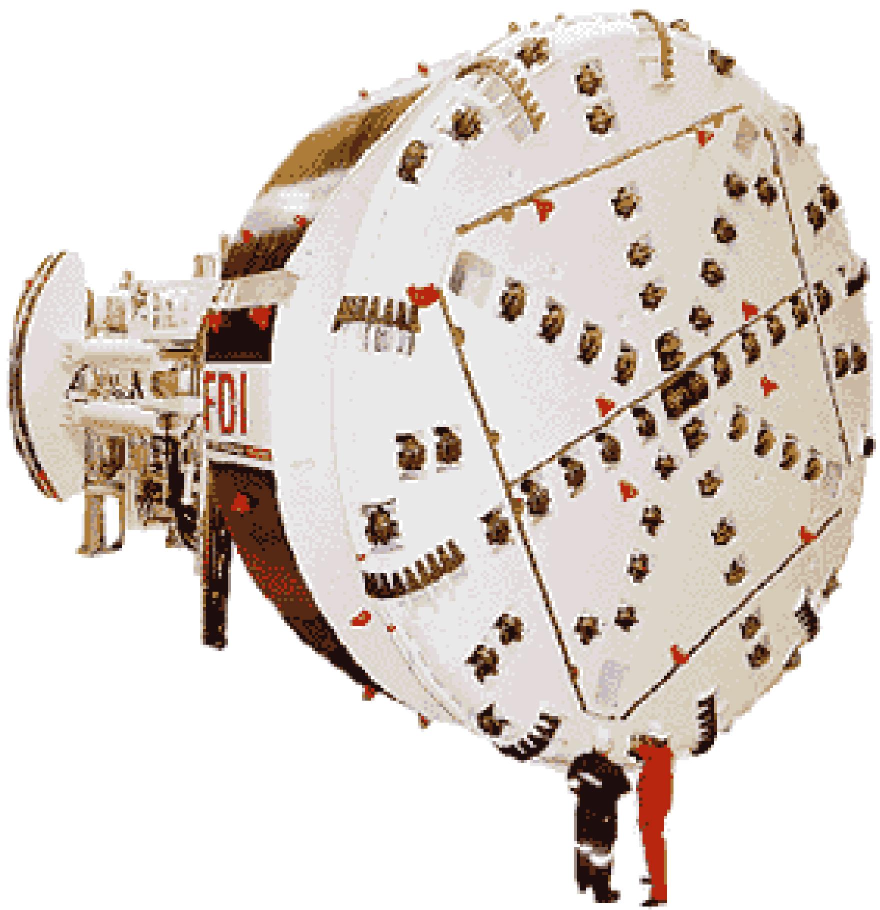
Dusseldorf Waterfront
Before & After Road Tunnel



Source: ITA

Rich National & Local Tunnel Legacy

- **Robbins -** The Robbins Company pioneered TBMs & has designed and manufactured hundreds of tunnel boring machines.
- **Herrenknecht-**Auburn
- **CTS-**Kent
- **Lawrence** Machine Co. - pioneer tunnel boring machine company, Seattle
- Agencies, Consultants and Contractors
- **Abundant Successful Local Tunnels**
  - **BN Tunnel (>100 yrs old)**
  - **Mt. Baker Ridge**
  - **Downtown Transit Tunnel**
  - **Beacon Hill**
  - **Brightwater**



Geology is a Dominant Factor to Tunnels

LOCAL GROUND CONDITIONS

- **Variable Soil Conditions**
  - **Portals**
    - **South Portal – Difficult mixed soft soils with obstructions**
    - **North Portal – Good soils; some obstructions**
  - **Main Bore**
    - **Primarily Hard but often sensitive soil conditions**
      - **Sandy & Silty Glacial Soil**
        - **Very sensitive to water**
      - **Clayey Glacial Soil**
  - **Generally Well Beneath Groundwater Table**

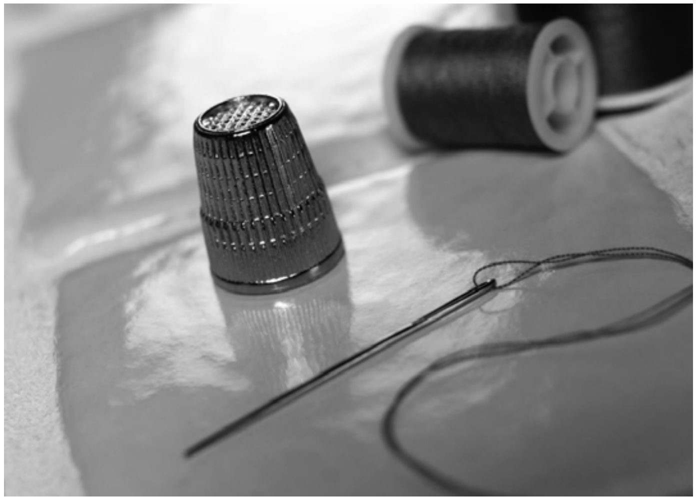
View of the South Beach Bluffs, Fort Lawton, Seattle

Significant Geologic Features

- Boulders
- Abrupt contacts
  - Flowing silt and sand
  - Till and Glaciomarine
  - Clay
- Erosional features
- High Groundwater Pressures
- Slickensided fractures
- Methane

Even After Comprehensive Soil Invesigations, Soil & Groundwater Conditions Ahead are Unknown

(Thimble to ~50 Oil Drums)



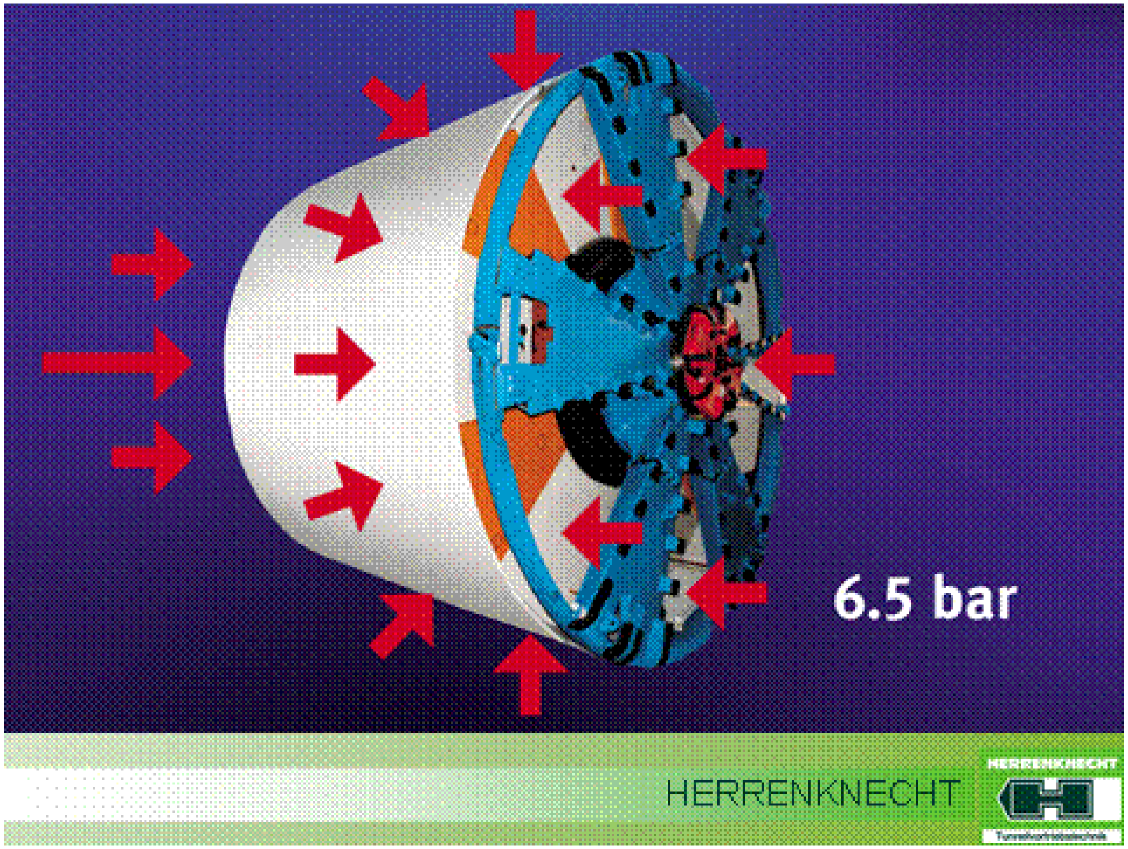
Designers & Contractors do a remarkable job
in spite of Vast Uncertainty

General Tunnel Approaches

- 1) Methods that Adapt to the Ground Conditions
  - TBM
    - EPB
    - Slurry
    - Mixshield
- 2) Methods that Improve the Ground
  - Dewater
  - Grout
  - Freeze
- 3) Combinations
  - Adaptable TBM supplemented by Ground Improvement
    - Special Zones and Cross Passages As Necessary

Tunnel Boring Machines

- Slurry and Earth-pressure balanced machines are essentially submarines operating in dense material



6.5 bar is 215 feet deep

Backup Systems – Slurry Separation Plant

Source: Herrenknecht

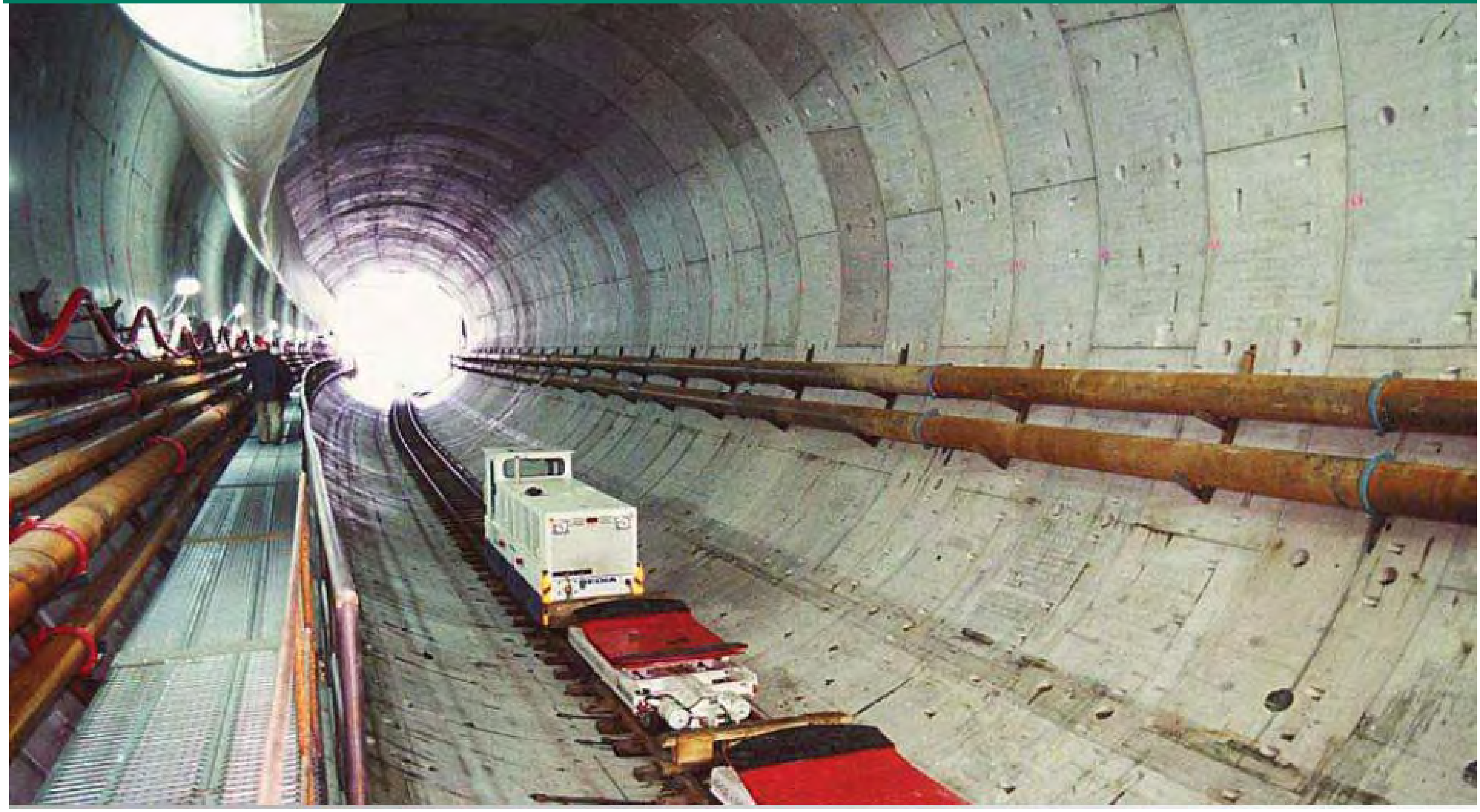
Robbins Channel Tunnel
Rail, 8m diameter, 10 bar pressure max

Source: Robbins

Tunnel Construction Disruption

- Generally much less than surface, cut & cover or elevated construction
- Primarily occurs during construction stage
  - Relocation & upgrading utilities
  - Construction
    - 24/7 but operations generally out of public eye
    - Portals & Shafts
    - Contractor’s yard
    - Incoming personnel & materials
    - Muck Disposal
      - Temporary storage on site
      - Haulage through streets to disposal site

One-Pass Precast Segmental Lining



Source: Herrenknecht, Elbe River Tunnel, 4th Bore

CONCLUSIONS: Alaskan Way Tunnel

- Gives Benefits Unique to the Tunnel Scheme
- Difficult but Technically Feasible
- Expensive
- Cost can be offset but not reduced by considering environmental benefits and life cycle costs

- Thank you for your attention