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Hudson River Tunnels, Mega Projects, and Risk – A Designer’s Perspective

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Hudson River Tunnels

- Project Overview
- Selected technical challenges
  - Shaft breakout
  - Cross passage construction
  - Timber pile removal
- Some project risk factors
- Mega Projects - Issues
Hudson River Tunnels Project

- Access to the Region’s Core (ARC)
- Trans-Hudson Express (THE) Tunnel
- Project Direction - Partnership
  - New Jersey Transit
  - Port Authority of New York and New Jersey
- Funding Formula
  - Federal Transit Administration - $3 billion
  - Port Authority of NY and NJ - $3 billion
  - State of New Jersey - $2.7 billion
  - Cost overruns – State of New Jersey
- Project cancelled by NJ Governor – October 2010
ARC Project - Major Tunnel Contracts

- **Palisades Tunnel** – *work was in progress*
  - Rock tunnels – twin, 5,100 ft long (diabase and sedimentary rock), 6 cross passages
  - Portal and 126-ft diameter Hoboken Shaft

- **Manhattan Tunnel** – *contractor selected*
  - 150-ft diameter 12th Avenue shaft, twin 130-ft long SEM adits at Hudson River Tunnels break-in
  - Rock tunnels – twin, 5,500 ft long (metamorphic rock), 6 cross passages
ARC Project - Major Tunnel Contracts

- Hudson River Tunnel (HRT) – under bid when project cancelled
  - Start from Hoboken shaft
  - Ground improvement and underpinning
  - Twin 7,200 ft long tunnels in rock, mixed-face, and soft ground, 24.5-ft i.d.
  - 9 cross passages (6 in soft ground)
  - Terminate at 12\textsuperscript{th} Avenue Shaft in Manhattan
Geotechnical Profile - HRT
TBM Type Selection - EPB

- Well suited to soils
- Avoids use of bentonite and slurry separation requirements

Baseline Grain Size Distribution for Stratum E1 (Hudson River and Manhattan)
Final Segmental Lining

- 5+1 universal segmented lining
  - 6 feet ring average length
  - 18 inches thick
  - Sixteen different positions to achieve alignment curvature

- Auxiliary elements: Steel bolts, dowels, alignment rods, packers, gaskets and hydrophilic rubber sealant
Hoboken Shaft - Stratigraphy
Hoboken Shaft Breakout

Main Considerations

- Control ground displacements due to volume loss in mixed-face tunneling areas
- Prevent groundwater drawdown and associated settlements in estuarine deposits
- Facilitate TBM launch and optimize TBM installation
Hoboken Shaft – Ground Improvement

- **Approach**
  - Block geometry
    - 5 feet below tunnel invert
    - 10 feet above tunnel crown
    - 120 feet long
  - Jet grouting system: triple fluid (per specs)
  - No access and overhead constraints
  - Contingency grouting program
HBLR Track Crossing – Light Rail

- Tunnel line
- Start of mixed-face
- Cross Passage
- Buried 230 kV cable
HBLR Tracks – Settlement Issue

- Approach
  - Jet grouting system: triple fluid (per specs)
  - Alternative methods to improve soil stiffness
    - Battered micropile canopy above tunnel crown
    - Compensation grouting program
    - Contingency grouting from first bore
Cross Passages in Soil

- Pilot test in CP-1
- Ground Freezing + Grouted pipe-spiles
- Ground Freezing – by Moretrench
Cross Passages in Soil

Construction Sequence

- Drill & install grouted pipe-spiles
- Drill & Install Stuffing Box Packer
- Start Ground Freezing Operation
- Install Temporary Support Frames & Bulkheads
- Demolish Segmental Lining
- SEM Top heading advance
- SEM Invert-Bench
- Install Waterproofing
- Permanent Lining
Cross Passages - Schematic

- Hoboken Shaft
- CP#1
- CP#2,3&4
- CP#5,6&7
- CP#8&9
- 12th Ave. Shaft
- Rock
- Soil
Bulkhead

- Concept and Details

Plan View - Proposed Protection Bulkhead

Elevation View - Proposed Protection Bulkhead

Detail - Proposed Protection Bulkhead

Purdue
Hudson River Bulkhead
Timber Pile Interference

**Sketch Showing River Tunnels Passing Under River Bulkhead Wall at Manhattan**

- **Mean High Water**
- **Mean Low Water**
- **Granite**
- **Foundation for Freight Shed**
- **Concrete Block**
- **Made Ground**
- **Hole caused by "blow" around Shield, afterward filled with Silt in bags which were weighted down by Rip-Rap**
- **Rip-Rap**

**Cross-Section of River Bulkhead Wall on Axis of North Tunnel**
Timber Pile Removal

PLAN SHOWING PILES REMOVED TO ALLOW PASSAGE OF SHIELD
Hudson River Bulkhead – Pile Removal

- No surface work allowed from river side
- No significant surface work allowed from land side
Project Risks – Design and Construction

- Stringent settlement limits
- Congested ground surface – limited access for ground modification
- Mixed face tunneling – soft soil and rock
- Hyperbaric interventions for TBM cutterhead maintenance below river
- Cross passages below river
- Manhattan Bulkhead – pile removal
Other Project Risks

- Schedule – liquidated damages
- One or two TBM’s?
- Insurance – Owner Controlled Insurance Program (OCIP) provisions
  - Professional liability – typical standard of care – “negligent performance of professional services” – sounds reasonable
  - No guarantee OCIP program will last through project – duty to provide equivalent coverage if owner opts not to continue
Project Insurance Provisions

- Professional liability insurance
  - **Minimum limit** - $10M per occurrence
  - Deductible – “up to” $10 M – borne by NJ Transit - *Briefly!*
  - NJ Transit then to make “Assessment” against insured parties – *negligence will not be the sole criteria* – no project limit
  - Ruinous upside potential and uninsurable as professional liability covers only negligent performance not contractual liability
ARC Issues

- ARC Project – a Mega Project
- Forecast cost overruns led to project cancellation
- Professional liability insurance provisions – poor risk for design engineers
- FTA audit found inadequate plans to manage project finances
External Risk Factors

- Mega Project complexity leads to external risk factors
  - Budget and schedule, contingency
  - Funding availability and stability
  - Owner’s PM structure, governance and decision-making
  - Owner realism and transparency
  - Owner’s contracting policies and decisions
Mega Projects are highly public and political

Studies show that expertise of project owner critical to project success

According to research, underestimation of costs and overestimate of revenues are frequent occurrences, and not necessarily based on error
“On the basis of the evidence…we conclude that cost estimates used in public debates, media coverage and decision-making for transport infrastructure development are highly, systematically, and significantly deceptive.”

Bent Flyvbjerg et al, Management and Risk.
“Noted commentators have concluded that cost underestimation and overrun have not decreased over the past 70 years. Cost underestimation and overrun cannot be explained by error and seem to be best explained by strategic misrepresentation, namely lying, with a view toward getting projects started.”

Bent Flyvbjerg et al, Management and Risk.
Smother Road for Megaprojects?

- Owner organizations should include large project experience.
- Cost estimates - range of outcomes, include a risk-based component.
- Risk register process becoming more common.
- Contracting should address equitable means of sharing and allocating risk.
- Standard of care and indemnification provision should be “negligence-based”.
Recommended Reading

“Mega Projects – Challenges and Recommended Practices” – edited by David J. Hatem and David H. Corkum, American Council of Engineering Companies