A Case Study for Waterproofing Below Grade Walls Shored with Continuous Soil Mix Technology Using a Bentonite Waterproofing System

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Outline

• Project Requirements
• Site History and Location
• Selection of Excavation and Shoring
• CSM Shoring Technology
• Selection of Waterproofing
• Installation and Field Conditions
• Troubleshooting
Initial Project Requirements

• Seven story office building with four stories of underground parking
• Located south of downtown Seattle near waterfront
• Project site with sensitive soil and high water table
• Maximum below grade depth of 45 ft.
• Average excavation depth of 36 ft below water table
• Need to minimize risks associated with soil conditions both during construction and over long term
Site History & Conditions

- Historic waterfront location south of downtown Seattle
- Reclaimed from Elliott Bay during re-grading at turn of century
- Infill contained significant construction debris
- Currently less than ½ mile from Elliott Bay
- High water table & tidal fluctuations of ground water
- Methane and Petroleum contamination
Site History & Conditions

- Adjacent historical buildings, structures, roads and utilities
- Sensitive to soil movement and settlement
- Adjacent historical building foundation required partial removal and replacement
- New micro piles to extend below current timber piles.
Excavation and Shoring Selection

• Significant dewatering of site required to excavate wood debris in fill.
• Dewatering of site for a drained shoring wall not practical and would drain surrounding settlement sensitive soils.
• Shoring needed to provide temporary lateral support to adjacent fill.
• Use of a shoring wall as a water tight cut off wall for dewatering of only the soils within the site required.
• Shoring to extend 25 ft below excavation depth to limit risk of seepage and base heave from deep aquifer.
Excavation and Shoring Selection

- **Typical soldier piles and lagging**
  - Not practical for this project due to soft and wet nature fill and marine deposits.
  - Does not cut off ground water flow into site.
  - Not as stiff as other shoring – risk of settlement of adjacent soils.

- **Steel Sheet Piles**
  - Not selected due to the depth of the excavation.
  - Risk of interference and blockage of sheets by existing fill debris.

- **Secant Piles**
  - Cost & schedule.
Excavation and Shoring Selection

- Cutter Soil Mixing Technology (CSM)
- Developed in Germany
- Uses cutter wheels to mix cement and bentonite clay slurry with soil in situ
- Overlapping soil-cement panels
- Resulting in solid and mostly water tight cut off wall
- Steel solider piles driven into the wet soil mix for strength
CSM Shoring Walls
CSM Shoring Walls Benefits

• Minimal Vibration
• Low noise
• Ideal for shoring in granular, contaminated and wet soils
• Drilling chews through any obstructions allowing for continuous vertical plane
• Can adjust strength of soil wall to project conditions
Anchoring

- Tie back anchors into CSM installed as excavation progressed
- Sleeves for tie back anchors provided in the steel soldier piles
- Horizontal steel whalers used where obstructions prevented tie back installation
Selection of Waterproofing

- Evaluated a variety of waterproofing systems based on project requirements
  - Use of CSM shoring wall
  - Desire to use Shotcrete applied structural foundation walls
  - Hydrostatic conditions
  - Possibility of Methane and Petroleum contamination
  - Proximity to Puget Sound - tidal fluctuations – salinity of water
- Considered approach of using a sheet membrane in combination with integral waterproofing concrete admixture
  - Found to be economically unfeasible
  - Owners accepted higher risk of water infiltration as a result of single system approach
Bentonite Waterproofing Membrane

- Selected approached used a dual layer of bentonite
- First layer mechanically attached to CSM
  - Minimum 4 inch laps for continuous membrane
- Second layer attached similarly
  - All laps sealed with bentonite mastic
- Samples of soil and ground water tested by the manufacturer for acceptable levels of salt and contaminants
- Use of HDPE liner on one layer of membrane limited leakage of methane into garage
Construction Considerations

• CSM Shoring Walls
  • Wavy CSM walls were acceptable
  • Bentonite membrane needed to be tightly secured against all variations in CSM
  • Large voids or protrusions in CSM needed to be smoothed
CSM Shoring Walls as Bentonite Substrate
Water Through CSM Wall

- Water seepage through the CSM walls at joints and tie backs
- Installed a gutter system to capture as much water as possible and keep it out of the site
Water Through CSM

- Water on slabs typical throughout waterproofing and shotcrete installation
- Drying and preparation of concrete joints required for waterstop
- Waterstop typically installed starting in early morning on day of shotcrete
- No time for water to build up and pre-hydrate bentonite
Water through the CSM

- Water seepage through CSM built up behind bentonite membrane
- Water would resist shotcrete pressure from pushing membrane against CSM
- Drainage slots cut into membrane 12 inch from slab levels
- Drainage slots vacuumed dry and then patched each morning prior to section of shotcrete
De-stressing and sealing tie backs
Troubleshooting

- Upon completion of construction, significant amount of water was noted seeping through cracks in concrete walls.
Troubleshooting

- Completed sample cores to review condition of shotcrete walls and bentonite membrane
- Revealed localized areas where foundation had separated from CSM shoring compromising confinement of bentonite
Troubleshooting

• Cause of the differential movement could not be conclusively established

• Post stressing of the below grade slabs were thought to be a likely contributor

• Bentonite grouting successfully used to fill voids and restore integrity of waterproofing
Conclusions

- CSM shoring wall successfully addressed the many challenges of excavating this site.
- CSM provided a suitable surface for application of waterproofing with minimal parging.
- Overall the CSM shoring wall performed well at minimizing water intrusion within the excavation.
- Water intrusion at tie backs required special considerations during installation of waterproofing.
- Consider the impact of post-stressing below grade slabs on the performance of the waterproofing.
- Bentonite grouting successfully used to fill gaps and restore integrity of waterproofing.
Thank You