Use of deep soil mixing for excavation retention and groundwater control

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Presentation format

- Project setting
- Proposed Solution - Deep soil mixing
- Retention design
- Construction
- DSM performance
- Conclusions
Project Setting
2010/2011 Canterbury Earthquake Sequence

- Peak ground acceleration of +0.6g in the Christchurch CBD.
- Widespread damage to commercial structures.
- Large scale liquefaction.
- Severely compromised 15,000 residential structures.
St Georges Hospital

- Damage to existing heritage buildings.
St Georges Hospital

- Damage to existing heritage buildings.
- Widespread liquefaction.
- Vertical displacement up to 1.5m.
Development objectives

- $120m (NZD) redevelopment works.
- Construction of 4 new buildings up to five stories + a single level basement.
- Importance Level 4 and 6 buildings.
Project objectives

• Retain 4m deep excavations in poor ground conditions.

• Control groundwater inflow during construction.

• Provide a robust foundation solution to address seismic risk including liquefaction, settlement and bearing capacity.

Project tender

• Arup submitted a successful D&C submission for Deep Soil Mixing with Highway Geotechnics.

• First use of deep soil mixing in Christchurch.
Proposed Solution - Deep Soil Mixing
Deep Soil Mixing (DSM)

- Insitu ground improvement.
- Mechanics mixing with a cementitious binder.
- To 25m depth.
- Typically 600-1200mm dia.
- Uses include: Slope stabilisation, liquefaction, bearing, excavation retention, settlement control.

Proposed Solution: Deep Soil Mixing
DSM Benefits

• Single solution for retention, liquefaction mitigation and foundation improvement.

• Reduced noise and vibration compared to sheet piling.

• Cost effective.

• Lower embodied energy.

• Strong QA – provides client confidence.
Proposed Solution: Deep Soil Mixing – DSM layout
Retention Design
DSM retention design

- 2D PLAXIS FEM using HS Small soil models based on CPT and sDTM testing.
- Properties of the grid DSM’s were ‘smeared’
- Small volume increase modelled as part of the DSM installation.
- Low tension cut off adopted in DSM’s
DSM retention design

- Internal and external triangular grid of 1.0m DSM @ 3.2m crs.

- DSM secant pile wall with DSM @ 0.85m crs.

- 8m long 150UC23 sections in every 3\textsuperscript{rd} column.

- Maximum target depth of 12m.

- 9m deep spanning piles for groundwater cut-off.
Position of first row of DSM columns outside the excavation

Wall displacement **with** rear DSM

Wall displacement **without** rear DSM
DSM retention reinforcing

• Questions regarding the ability of the DSM and a smooth UC to act as a composite member.

• Conventional design is to consider only the reinforcing members (Rutherford et al, 2007).

• 3 Cases were assessed during modelling with the UC reinforcing:
  • Full DSM;
  • Half (compressive) DSM; and
  • No DSM.
DSM Design – UC reinforcing sensitivity: 3 cases (with and without overdig)
DSM Intermediate support design

- Concepts of improved ground as lagging
- Adopted solution of offset piles

DSM Design - Retention design
DSM Construction
DSM Construction – Installation of trial columns
DSM core samples

DSM UCS strength testing
DSM wall performance
Dry conditions with minor dampness in lower part of columns
Cracking behind DSM columns

- Approx 10mm wide.

- Single continuous crack.

- Supports the provision of reinforcement.

- No cracking on the DSM face or effect on water retention.

- Access restriction behind this wall, so no rear DSM’s.
Conclusions
Conclusions

• The use of deep soil mixing resulted in cost and construction efficiencies due to its adaptable nature.

• Low noise and vibration resulted in minimal impact on hospital operations.

• DSM’s preformed well as groundwater/retention solution.

• Opportunities to refine the interaction between DSM’s and steel reinforcing inclusions
Questions?