Design of Temporary Excavation and Lateral Support System for the DSD Sheung Wan Stormwater Pumping Station

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**Project Set Up**

- **DSD Contract DC/2006/10**
- **Contract Sum**: HK$ 78 million (approx)

- **Designer**: Drainage Services Department  
  (with GEO as in-house geotechnical consultant)
- **Site Supervision**: DSD Drainage Project Division  
  (with the engagement of an IGE)
- **Contractor**: China National Chemical Engineering Group
- **ELS Designer**: Geotechnical Consultant Group (Asia) Ltd.

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**Pile Cap Layout Plan**
Selection of Retaining Wall Type

Wall Types Considered:
- Diaphragm Wall
- Bored Pile Wall
- Pipe Pile Wall
- Sheet Pile Wall
- No wall (open cut)

Design Objectives:
- Approximate max. 10m deep excavation
- Effective control of settlement due to excavation and groundwater drawdown
Reclamation and Seawall Dredging Plan

Typical Cross Section

Approx. Location of Site

Approx. Extent of SWSPS

Vertical Seawall (Indicative)

Victoria Harbour
Pre-Contract Ground investigation

- 2 series in 2002 & 2006 (32 holes)
- Common sampling, field and laboratory tests
- In situ vane & pressuremeter tests

Pre-Contract Borehole Location Plan

North-South Geological Section

- Fill
- Rock Fill
- Sand Fill
- Marine Deposits
- Alluvium
- CDG
East-West Geological Section (away from Seawall)

Isopach of Soft Marine Clays

_existing_salt_water_PS

_fi_l

_mari_ne_deposit

_alluvium

_CDG

_seawall_cape_line
Small sink hole at sea wall

5m³ sink hole
15m³ sink hole

Settlement near Seawall

Settlement (m)

SS1
SS2
SS3
SS4

SS' Markers on Seawall

GS20
GS21
GS24
GS25

GS' Markers on Ground Adjacent to Seawall
Design Considerations

- Reclamation Site
- Sensitive Structures nearby, i.e. WSD Pumping Station
- High water table, i.e. 1.2m below existing ground level (+3.0mPD)
- Presence of thick layer of variable FILL & soft MARINE DEPOSITS

Design Methodology

- Drained and Undrained Conditions
- Lateral Stability
- Global Slope Stability
- Base Stability
- Hydraulic Stability
- Dewatering
- Ground Deformation / Settlement
- Structural Capacities
Longitudinal Cross Section nearest Seawall

Transverse Cross Section
Elevation of Wall D
(Showing Grouting Ground Improvement)

Elevation of Wall D
(Showing Grouting Ground Improvement)

Finite Element Analysis
(East-West Section)
Wall Deflection (East-West Section)

- East Wall: $\delta_{\text{max}} = 60\text{mm}$
- West Wall: $\delta_{\text{max}} = 115\text{mm}$

Ground Settlement (East-West Section)

- West Wall: $\delta_{\text{max}} = 18\text{mm}$
- East Wall: $\delta_{\text{max}} = 82\text{mm}$
Wall Deflection (North-South Section)

South Wall

$\delta_{max} = 102\text{mm}$

North Wall

$\delta_{max} = 88\text{mm}$

Ground Settlement (North-South Section)

South Wall

$\delta_{max} = 53\text{mm}$

North Wall

$\delta_{max} = 75\text{mm}$
Deformation of Seawall

Slope Stability Analysis (South Wall)
**Instrumentation Layout Plan**

- Principal Instrumentation:
  - Ground settlement markers (SS, GS, SA)
  - Inclinometers (IN, INX)
  - Standpipe Piezometer (SP, PZ, PP)
  - Building Tilt Marker

**Outline Construction Programme for Key Activities**

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HKIE Technical Talk – ELS Design for SWSPS – 18 June 2008
Ground Settlement Time Plot behind North Wall (Seawall)

Ground Settlement Time Plot behind East Wall
Ground Deformation behind East Wall
(due to excavation only)

Ground Settlement Time Plot behind West Wall

Predicted $\delta_{\text{max}} = 82\text{mm}$

Predicted $\delta_{\text{max}} = 115\text{mm}$

Settlement against Time

Predicted $\delta_{\text{max}} = 18\text{mm}$
Jet grouting

- Jet grout cuts in situ soft clay and mixes that with injected cement
- Disturbed clay is displaced to surface in slurry form
- Jet nozzle is typically 1.4mm to 3mm dia.
- Applicable to more cohesive soils where T.A.M. grouting may not work
Typical Set up of Jet Grouting
(Double Tube Method)

Temporary casing for drilling through fill withdrawn prior to jettting (optional)
PVC tubing to assist spoil return (optional)

1. Set up rig
2. Drill to toe level
3. Test jetting
4. Commence Jetting
5. Simultaneously withdrawal and rotation of grout string to next level
6. Jet grout completed. Withdraw grout string

Sequence of Jet Grouting
Ref. : CNCEC
Jet grout parameters

- Jet grout parameters adopted at SWSPS
  Target grouted dia. = 1500 – 2000 mm
  Grout pressure = 300 – 400 bars
  Air pressure = 8 - 12 bars
  Withdraw rate = 13 to 15 min/m
  Rotation rate = 6 – 7 rev/step

- Target strength & stiffness
  UCS = 600 kPa
  Elastic modulus = 150 MPa
Hole S5  
Hole S2  
(UCS: typically 7-10 MPa, sometimes >40 MPa)  
Jet Grout Core Sample

T.A.M. Grout Core Sample
Sheetpiling (by push-in method)

- Suitable in area where vibration is undesirable
- With limited penetration depth
- Difficult to overcome obstruction
- Tend to be more costly
Sheetpiling by push-in method

At SWSPS

- Giken rig with special tool to overcome obstruction (up to 1m)
- Maximum 24m long sheet pile
- Limited to Type IV sheetpile
Augering to assist penetration
Alignment out-of-line when encountering obstructions

Groundwater leaking through retaining wall
Excavation in progress

Disposal by barge
Installing waling and strut

Excavation completed
Concreting in progress
(3 concrete pumps & 13 concrete trucks)
Foundation Completed
Summary

Issues to be considered in ELS design

- Site history
- Site characterization
- Design parameters (drained or undrained)
- Design objective and constraints
- Retaining wall installation effects
- Economy and construction programme
Acknowledgement

- Drainage Services Department
- China National Chemical Engineering Corp
- Hyder Consulting Limited

Thank You!