Innovating with Segmental Caisson Construction to Build a New Pump Station in Wellington’s CBD

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Asset Owner – Wellington City Council
Client – Wellington Water
Designer – GHD Ltd
Contractor – Brian Perry Civil
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- Extent of Works
- Challenging the Conventional Approach
- Seismic Loading
- Complex Site Constraints
- Delivering Construction
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  - Groundwater Drawdown Risk
Developments to be constructed by 2021

- Existing sewer network at full capacity
- 65,000 pop. increase (30y)
- 7300 new CBD dwellings
- New Pump Station preferred solution to permit growth in the CBD
- First new PS for 40 years
- Reduce overflow spills to harbour

The Need

**Customer Outcomes**

**Safe & Healthy Water**
- Protect public from untreated spills to ocean

**Respectful of the environment**
- Ensure water services in built environment comply with consents and unintrusive

**Resilient networks support the economy**
- Provide customers access to reliable wastewater services
- Provide wastewater networks that are resilient to shocks and stresses
- Plan to meet future growth and manage demand

**CHALLENGES**

- Existing sewer network at full cap
- 65,000 pop. increase (30y)
- 7300 new CBD dwellings
- New Pump Station preferred solution to permit growth in the CBD
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**LOCATION?**

Developments to be constructed by 2021
Extent of design

- PWWF – 73 l/s
- Below ground structure, 8m deep
- Divert 2 catchments
- Pipework
  - 60m x 300mm PE gravity
  - 170m x 250mm PE pressure
- Connect to interceptor gravity sewer
- Emergency Overflow weir structure
Challenging the Conventional

- Limited site locations and associated space
- Traditional approach
  - Cast in-situ – sheet piled excavation (or similar)
  - Cast on-site standard caisson structure
- Initial design – 7.8 x 5.2 x 6 m (d) concrete box

Initial Construction Review Issues
- Installation Noise / Vibration
- Close proximity to roads, buildings and pedestrians
Tender Innovation Sought

**Potential benefits of Precast Concrete Segmental Caisson**

- Common in Europe
- Quicker installation
- Safer – deep excavations
- Quieter
- Reduced footprint

**Complexities in New Zealand**

- Segment availability
- Seismic performance
- NZ Design Standards

- 1m deep precast concrete segments
- Joined to form rings
- Excavate from inside
- Hydraulic jack assisted

© FP McCann – Precast Tunnel & Shaft Solutions
Tender Innovation sought

- Potential benefits of Precast Concrete Segmental Caisson
  - Common in Europe
  - Quicker installation
  - Safer – deep excavations
  - Quieter
  - Reduced footprint
  - Cost Savings
  - Less Disruption
  - Invited innovation
  - Alternative design
  - 6.5m internal dia.

- Complexities in New Zealand
  - Segment availability
  - Seismic performance
  - NZ Design Standards
  - POTENTIAL TENDER
    - Seismic Conditions
    - Can it be built?
  - TENDER REVIEW
  - 6.5m dia not available in NZ
  - Shipped direct from UK

- Successful Contractor Methodology
  - Perfect for site constraints
  - Preserve pedestrian and vehicle access
  - Reduce disruption to businesses
  - Retain existing urban streetscape and vegetation

TENDER AWARD
- Preconstruction stage
- Collaboration
- Designer / Contractor
Internal Walls – Seismic Loading – Critical Asset

- Wetwell / dry well configuration
- Internal wall design to NZ Building Code
- Fire assessment
- Access and egress
- 3D Model brought design to life

- Water retaining structure
- Importance Level 4
- 100y durability
- 1 in 2500y ULS event
- Internal walls
Internal Walls – Seismic Loading – Critical Asset

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- Seismic model assessment by contractor sub-consultant
  - Connections of internal walls and their effect on segments
    - Continuous wall (full height)
    - Movement of individual segments
  - Maximum limit of joint displacement
Challenging Site Constraints

- Small site footprint
- Shallow Foundation buildings (5m)
- Live road (1m)
- Existing trees
- Consents
  - Contaminated Land
  - Dewatering Consent
  - Building Consent
- Noise Management
Rising Main and Gravity Pipeline Construction

• Horizontal Directional drilling of rising main

• Traffic management in Wellington CBD

• Construction site loading zone
Site Establishment

- Service Diversions
  - Storm water
  - HV Power
  - Telecom

- Tree
  - Moved PS 300mm further away

- Streetlight

- Traffic Management

- Pedestrian Safety
Cutter Ring

- Precast segments
- 10 segments = 1 ring
- Taper on cutter ring
- Shear Key for concrete base plug
First Standard Ring
Construction of Reinforced Concrete Collar

Collar Benefits:

• Trench support
• Reaction mass for Hydraulic Jacks
• Vertical Guide
• Anti-flotation structural mass
Caisson Build, Excavation and Sinking

- 24t “no swing” excavator
- Sandy Silt
- Spoil transferred to trucks on road
Caisson Build, Excavation and Sinking

• Custom-made Clamshell Bucket

• Caution working around tree

• Groundwater reached (4.5m BGL)
Connecting Segments

Tapered Joint for final segments in ring
Formation level reached

- 7 Rings in 21 days
- 7.8m deep
- 700t soil excavated
Caisson concrete base plug and dewatering

• Managing contaminated groundwater
  • Hydrocarbons > Trade Waste Consent limit
  • No discharge to sewer permitted
  • Mobilised 3 x 40m³ storage tanks
  • Time to settle before discharge
  • Significant cost implications

• Groundwater drawdown risk to surrounding buildings
Concrete base plug – Groundwater drawdown & risk of settlement in buildings
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- U/S Sensor in monitoring bore hole
- Online Real-time data feedback (every 5 mins)
Concrete base plug – Groundwater drawdown & risk of settlement in buildings

- Drawdown water level inside caisson to improve accuracy of concrete plug placement
Concrete base plug – Groundwater drawdown & risk of settlement in buildings

- Determined ALARM levels
- Pump started, low flow rate (2 l/s)
- No movement in BH level

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<td>60 mins</td>
<td>- No significant change, therefore pump increased to max output of 5.7 l/s</td>
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| B – C | 120 mins   | - 50% target water level in caisson  
- BH water sensor level tracking above estimated drawdown profile, no risk of settlement  
- Tracking line of water levels in BH v’s caisson were diverging which increased confidence  
- Confirmed safe to proceed with 56m³ concrete delivery to complete base plug installation |
| D     | 160 mins   | - Pump failure, switched over to standby pump |
| E     | 220 mins   | - Target water level in caisson reached  
- BH water sensor level remained above alarm level 1 confirming no risk of settlement |
Concrete base plug – Groundwater drawdown & risk of settlement in buildings

• Level drops quicker in caisson than in borehole – good confidence
• 50% water level in caisson
• Concrete order confirmed with batching plant

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Concrete base plug – Groundwater drawdown & risk of settlement in buildings

- Caisson target water level reached
- BH Level remains above ALARM 1
- Concrete pour begins

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A-E - Groundwater Drawdown  
Start of Concrete Pour  
Contaminated top layer removal  
Concrete base plug completed  
Groundwater recharged 24 hours later
Internal Floor and Walls

- First time workers enter the Caisson
- Wall connections
- Reinforced floor slab
Internal dividing walls

- Separation for wet and dry well
- Pre-cast wall panels
- Connection design for cast in-situ
- 100t mobile crane for lift
Structural Floor and Mechanical fit out

• Mezzanine floor supported off precast corbel

• Pumps and pipework installation

• Electrical control board installation
Precast Concrete Roof Slab Placement

- 400mm thick slab
- 100t mobile crane
- 18.5t load
- 2 week programme saving

2 week programme saving
Reinstatement
Completed internal fit out of dry well
Reinstatement – hidden out of sight

- Custom made lift assist access cover
- Extendable handrails
- Paver infill access covers
What did we find

• What we were looking for
  • Quicker construction
  • Safer working environment
  • Reduced noise
  • Smaller footprint
  • Minimised disruption

• Contaminated ground / water biggest challenge
  • Correct methodology
  • Real time data

• Collaboration is key to safe and successful delivery
  • Pre-construction design stage
  • Geo / Str Eng input critical

• Unique in NZ (as far as we know)
  • Innovative integral internal wall design
  • Inside a precast segmental water retaining structure
Thank you – Questions?
INNOVATIVE SEGMENTAL CAISSON CONSTRUCTION FOR A NEW PUMP STATION IN WELLINGTON'S CBD