MEYERCRUDEN
CIVIL | STRUCTURAL | GEOTECH

POLE FOUNDATION BACKFILL TESTING

PRESENTER: CAMERON MCNOE

INSERT DATE: 20/5/21

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MY BACKGROUND

- Studied Engineering at University of Canterbury
- Working as a structural engineer for 6 years working for Delta (2015) and Meyer Cruden Engineering (2015-2021)
- Work on a range of structural projects: Including industrial, commercial & residential structures and overhead power lines.

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INTRODUCTION

- **ENGAGUED BY AURORA TOINVESTIGATE POLE FOUNDATION CAPACITY WITHOUT CEMENT STABLISATION**
  - **Site visits to assess existing backfill methodology used by different contractors on the Aurora Network**
  - **Desktop investigation into pole foundation theory**
  - **Full scale pole foundation testing using range of backfill methodologies in loose sandy soils in Cromwell.**

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SITE OBSERVATIONS

- **Inspected 3 separate pole installs by different Aurora Contractors.**
- **Poles in Dunedin/Central Otago**
- **Mixture of cohesive/granular soils**
- **Backfilling procedures varied significantly between contractors**

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SITE OBSERVATIONS – GENERAL COMMENTS

- Different excavation types – sucker truck/digger
- Compaction with pneumatic rammer attached to hiab
- Backfill with crushed AP40/AP25
- Cement quantity varied or was not used
- Difficult to achieve good compaction in base of deep narrow foundations
- Difficult to compact in loose granular soils without collapsing

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SITE OBSERVATIONS – ITEMS DONE WELL

- Generally, fill placed/compacted in thin layers (100-150mm)
- Generally, decent amount of time spent compacting each layer of backfill (1-2 mins)
- Backfill placed with shovels/digger bucket in layers of 150mm or less
- Crushed granular backfill
- Oversized trenched foundations dug perpendicular to the load direction

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SITE OBSERVATIONS – ITEMS COULD BE IMPROVED

- Backfill placed in very thick layers of up to 600mm deep. Generally, the result of backfill being poured into the hole directly from the bag.
- When used cement was not well mixed with backfill. Generally, shaken from bag into footing during compaction.
- Often would run out of cement
- Inadequate granular backfill when footings over excavated. Spoil used in place of granular backfill.
- Excavated oversize rocks placed around pole.
- Backfill compacted at ambient moisture. Unlikely to be optimal for compaction.

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//M METERENGINEERING — SP 1

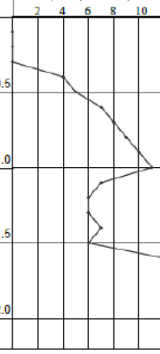
SOILS TEST RESULTS

JOB No. 2020009 DATE : 14/7/20

PROJECT: 45 Branxholm St WEATHER : Fine

Pole Backfill FEILD STAFF : CM

	SOILS DESCIPTION	No of Blows	Depth (m)	Scala (Blows per 100mm) 2 4 6 8 10	Shear Vane
	Loose granualr backfill with oversized boulders				
	Cement Stabilised AP40 backfill	4			
0.5		5	0.5		
		7			
		8			
		9			
		10			
1.0		11	1.0		
		7			
		6			
		6			
		7			
1.5		6	1.5		
		12			
		17			
		30			
	Oriognal Ground (Silty gravel with oversize				
2.0	boulders)		2.0		



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SITE OBSERVATIONS – SCALA TEST

- **Results indicate inconsistent compaction throughout footing depth**
- **95% theoretical maximum compaction for AP40 would generally result in blow counts in the 30s or above**

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SITE OBSERVATIONS – RECOMENDATIONS

- **Develop a consistent procedure for pole backfill to be adopted across Aurora Network**
- **Consistency around backfill material, cement, layer thickness & compaction**
- **Allow for testing/design of standard foundations**

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POLE FODATION THOREY

- Current practice uses simplistic ULS methods – Brinch Hansen (AS/NZS7000:2016) & Broms (NZBC B1VM1).
- Pole foundations need to rotate to develop this capacity. ULS methods don't calculate rotation.

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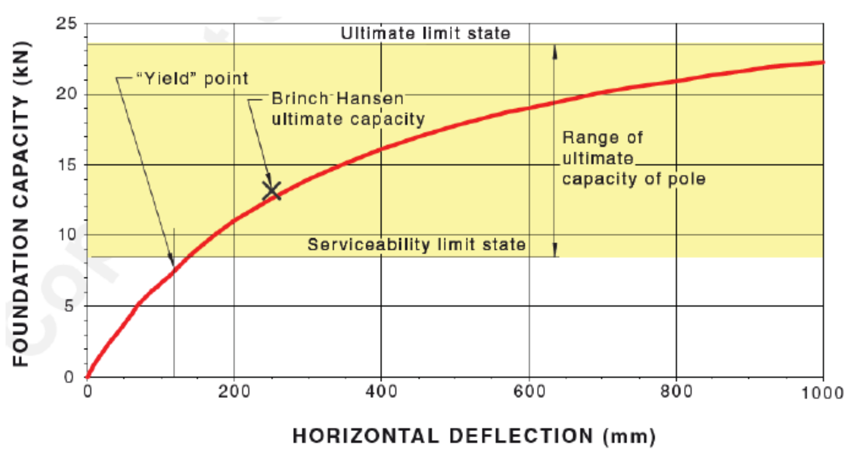

Figure 5: Typical Pole Foundation Load/Displacement Curve

SA/SNZ HB331

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POLE FODATION THOREY – CEMENT vs NON CEMENT

- **AS/NZS7000:2016 L3.3.1 Brinch Hansen Method:** ***"The effective diameter can be taken as the average pole diameter below ground for soil backfill situations and the auger diameter where concrete or soil/cement backfill used"***
- ***Use of cement significantly increase capacity when designing to AS/NZS7000:2016.***
- ***Calculated theoretical capacity generally below the rated capacity of the pole***

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Table 1: Loose Sands Foudnation Capacity

Pole Type	9m Hardwood	11m Hardwood	12.5m Hardwood	B9.5 Busck	B11 Busck	B12.5 Busck	B12.4 Busck
Pole ULS Capacity	12kN	12kN	12kN	13kN	22kN	22kN	43kN
Footing Depth	1.5m	1.8m	2.1m	1.6m	1.8m	2.1m	3.2m
Pole Groundline Diameter	285mm	300mm	315mm	160mm	240mm	255mm	300mm
900mm ϕ AP40 Cement Stabilised Compacted Backfill (ASNZS 7000:2016 "Brinch Hansen Method")	3.6kN	5.3kN	7.7kN	4.2kN	5.3kN	7.7kN	31kN
900mm ϕ AP40 Compacted Backfill (ASNZS 7000:2016 "Brinch Hansen Method")	1.5kN	2.3kN	3.5kN	1.2kN	2kN	3kN	14kN
900mm ϕ AP40 Compacted Backfill (NZ Building Code "B1/VM1")	5.9kN (2.9kN)	8.7kN (4.3kN)	11.5kN (5.8kN)	4.2kN (2.1kN)	7.8kN (3.9kN)	11.6KN (5.7kN)	40kN (20kN)

Notes
- Soil properties ϕ =30° and ϒ=18kN/m3
- Capacities given are for short term loadings
- Bracketed values are factored capacities
- Strength reduction factor for Brinch Hansen method ϕ = 1.0 (Foundation design to yield before pole structure)
- Strength reduction factor B1/VM1 ϕ = 0.5
- Non cement stabilised values based on pole diameter & moment capacity at ground line

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POLE TESTING

- Significant number or variables that could be investigated
- Limited resources so looking to get the best "bang for buck with testing"
- B11m poles – most common in Aurora network
- Comparison of ideal cement/non-cement stabilized foundations
- Test each pole in 4 directions
- In-line poles without blocks
- Testing in loose granular soils to get a lower bound on capacity

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POLE TESTING - INSTALL

- Loose sandy soils
- Excavated with a digger with trench parallel to strong face
- Major issues with collapsing of footing, especially when compacting.
- Compaction focused to 900mm diameter of pole with remaining footing backfilled with uncompacted AP40/spoil. (Typical of foundations in loose granular soils).
- Cement mixed through AP40 with cement mixer (ideal test) and digger bucket (linesmen method)
- Compaction 2-3 mins per 150mm layers to achieve "maximum feasible compaction"

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POLE TESTING - INSTALL

- **Foundations left 1 month to allow for "setting in period"**

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POLE TESTING - TESTING

- Hiab with load gauge read from bucket truck
- Fabricated steel testing rig to measure deflection at pole top and provide datum to hand measure ground line deflection
- Loadings to ~1/2 of pole rated capacity

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POLE TESTING - RESULTS

- Lower rotations/higher capacities for cement stabilized foundations
- Cement vs Non Cement: Generally, about 2x the pole rotation to achieve the same capacity
- Capacities calculated greatly exceed the theoretical values
- Marginally increased capacity under reversed strong axis loading (2nd test)
- Much lower capacity achieved for weak axis load tests (3rd & 4th test). Limited benefit from results.

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Table 1: Across Line Tip Load vs Ground Line Rotation

	POLE GROUND LINE ROTATION					
Pole Type	1°	1.5°	2°	3°	4°	5°
AP40 No Compaction 1 (Pole 1)	0.8 kN	1.3 kN	1.6 kN	2.5 kN	3.0 kN	
AP40 No Compaction 2 (Pole 2)	1.2 kN	1.4 kN	1.7 kN	2.3 kN	2.6 kN	2.9 kN
AP40 Compacted 1 (Pole 3)	4.4 kN	5.6 kN	6.5 kN	7.9 kN		
AP40 Compacted 2 (Pole 5)	4.9 kN	5.9 kN	7.0 kN	8.1 kN	9.3 kN	
AP40 Compacted w/Cement 1 (Pole 6)	9.4 kN	11.0 kN				
AP40 Compacted w/Cement 2 (Pole 7)	8.4 kN	9.4 kN	10.4 kN			
AP40 w/Cement (Linesman Methodology) (Pole 8)	8.1 kN	8.6 kN	9.4 kN	10.4 kN		

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Table 3: Reverse Across Line Tip Load vs Ground Line Rotation

	POLE GROUND LINE ROTATION					
Pole Type	1°	1.5°	2°	3°	4°	5°
AP40 No Compaction 1 (Pole 1)	2 kN	2.3 kN	2.6 kN	3.5 kN	4.2 kN	4.9 kN
AP40 No Compaction 2 (Pole 2)	2 kN	2.2 kN	2.4 kN	3.4 kN	3.5 kN	
AP40 Compacted 1 (Pole 3)	6 kN	7 kN	7.6 kN	8.7 kN	9.7 kN	
AP40 Compacted 2 (Pole 5)	6.6 kN	7.3 kN	7.8 kN	8.4 kN	9 kN	
AP40 Compacted w/Cement 1 (Pole 6)	7.7 kN	9.0 kN	10.1 kN			
AP40 Compacted w/Cement 2 (Pole 7)	10.1 kN	11.3 kN				
AP40 w/Cement (Linesman Methodology) (Pole 8)	8.1 kN	9.5 kN	10 kN			

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FUTURE TESTING

- **Testing of foundations to pole capacity (H+S issues)**
- **Testing in a range of soils (cohesive/granular)**
- **Testing different cement ratios and mixing techniques**
- **Testing of different compaction methodologies (Time, layer depth and focused compaction)**
- **Testing of different foundation depths**
- **Testing of poles with blocks**

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QUESTIONS?

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