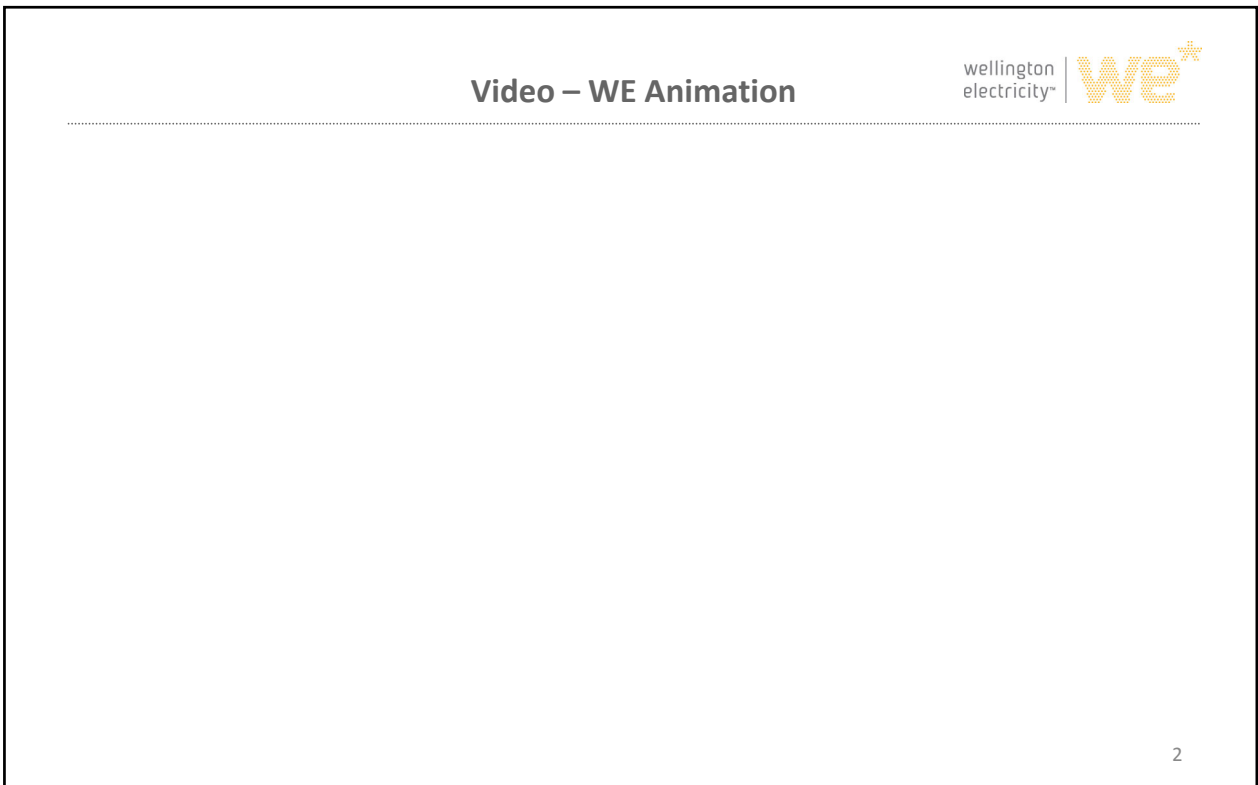




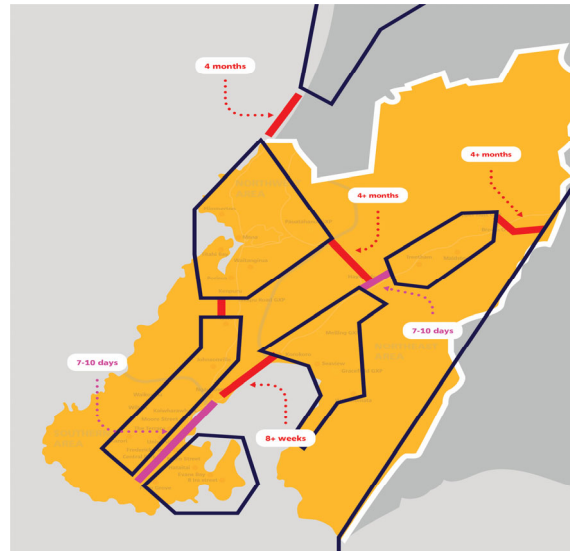
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Background

- Wellington region is a high earthquake risk area.
- Underground (fluid filled) cables are vulnerable to ground disturbance.
- Long term cable replacement programme is being planned (resilience).
- Shorter term contingency plan is prudent (readiness).



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Introduction


- WELL submitted a “streamlined” customised price-path (SCPP) application in November 2017.
- In March 2018, the Commerce Commission granted WELL its request of \$ 31.2m.
- The expenditure is for:
 - Mobile substations and switchboards
 - Critical emergency spares
 - Enhanced communication systems
 - Strengthening of substations.
 - **Emergency OH hardware**



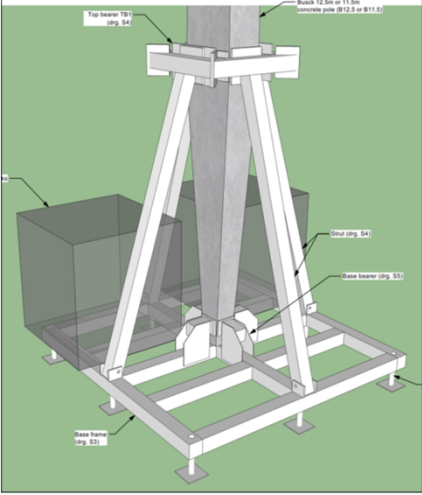
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The Two Designs

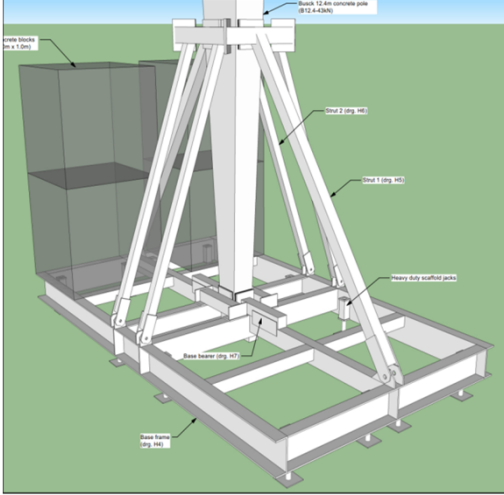


Light Duty Foundation



- Light design uses 4 anchor blocks
- HD design uses 8 anchor blocks
- HD design is 8 x stronger - (2 x more blocks and they are off-set further).
- Designed for concrete poles but timber can be used.
- Both designs can adjust to sloping terrain using inbuilt levelling jacks


Heavy Duty Foundation




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Load Testing System



- Linetech test process - Ashhurst Engineering site, hardware and personnel.
- Busck 43kN pole used to minimise chance of a pole failure.
- Loads applied directly to pole top via a crane
- Remote reading Bluetooth load-cell used to monitor top loads.



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Development Process

- Mk I designs produced, prototyped and load tested.
- Heavy Duty foundation failed load testing.
- Numerous design improvements identified.
- Mk II designs produced, prototyped and load tested.
- Both Mk II designs passed load testing.



Mk I Prototype under test

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Light Duty Mk II Foundation Load Test

- Four anchor blocks on the foundation.
- Easily passed the design type test top load of 458kg with no issues.
- Current loading constraint is overturning moment due to block weight, not foundation steel strength.
- Potential for rerating this foundation for higher loads using three blocks per side. A new test would be required.



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Heavy Duty Mk II Foundation Load Test

- Design was for 8 x 1m³ anchor blocks each weighting 2 tonne
- 10 concrete anchor blocks used: 900 x 870 x 870 - 1.67 tonnes each for large foundation (to approximate 8 x 2.2 tonne 1m³ blocks)
- Test top load of 3570 kg achieved and sustained with no damage to the foundation.



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Field Testing # 1 Upper Hutt

- Light duty foundation used with a wood pole .
- Temporary rural bypass for slip threatened pole.
- Digger used to install foundation, blocks and pole.
- In service for nearly 3 months
- Numerous detail design improvements identified.



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Field Testing # 2 Island Bay

- Small foundation
- Temporary O/H to U/G cable transition pole
- May 2018
- In service just 10 days.



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Recent Design Improvements 1

- Lay down struts that facilitate strut & pole install.
- Solid top collars with interlocking pins/holes.
- Footing jacks installed to level foundation.

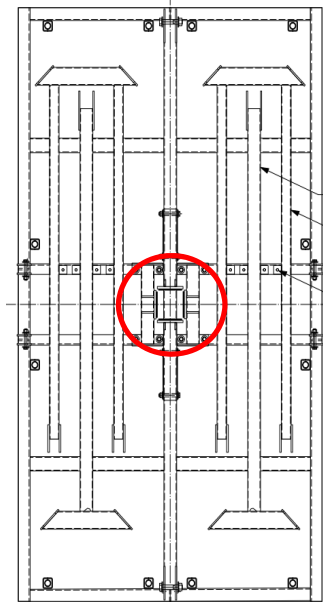
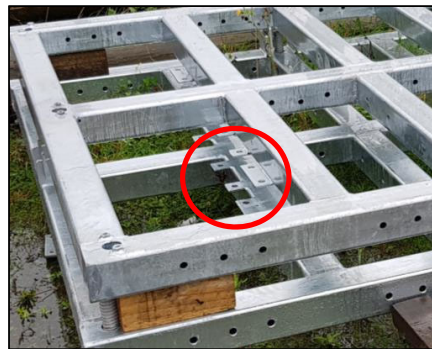
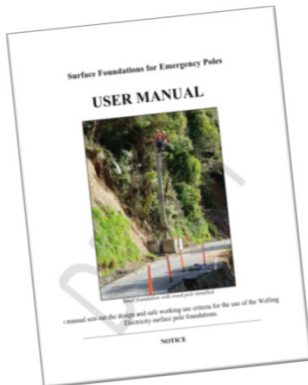


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Key Design Improvements 2

- Flat pack design – strut arms bolt flat to foundation for storage and transport
- Specially-made concrete anchor blocks
- User manual developed



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Video - Final

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Conclusions

- Multiple emergency overhead line routes designed to allow any damaged cables to be bypassed.
- Emergency Lines to use surface foundations in locations where excavations are problematic.
- The two emergency foundation designs have successfully completed prototyping, load testing and initial field testing.
- User manual has been developed to ensure safe installations.
- Volume production is underway as part of WELL's earthquake readiness project.
- Designs to be made available from WELL for others to use on application.

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