# North Auckland and Northland 220kV Cable Project – Managing Thermo-Mechanical Forces in Large Conductor XLPE Cable Circuits

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## ABSTRACT

*The North Auckland and Northland (NAaN) cable project is one of the most interesting and technically challenging long length land cable routes in the world, involving a major bridge crossing, a shared long length deep tunnel and buried duct routes, which pass through the centre of a major city.*

*The Utility recognised that sound thermo-mechanical design is an essential foundation for in-service reliability of large conductor 220kV 2500mm² XLPE cable systems.*

*Contractors were required to measure cable mechanical parameters and demonstrate the strength of cable system components and then validate the thermo-mechanical designs with FEA simulation techniques.*

## KEYWORDS

Auckland, NAaN, thermo-mechanical forces, XLPE cable, duct, tunnel, bridge crossing, rigid section, flexible section, transition section, locking wave, mechanical parameters.

## INTRODUCTION

Auckland, the largest city in New Zealand, is almost completely surrounded by water. The City, coloured in grey in Figure 1, occupies a narrow isthmus between the Manukau Harbour on the Tasman Sea to the southwest and the Waitemata Harbour on the Pacific Ocean to the east.

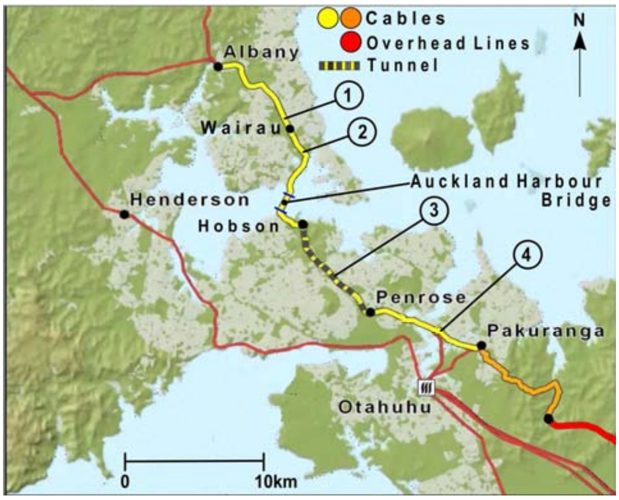


**Fig. 1: NAaN project completes the Auckland ring**

The central business district (CBD), item 3, lies adjacent to the Hobson Substation and is separated from the Northshore area of Auckland, items 2 and 1, by the Waitemata harbour. This is crossed by the Auckland Harbour Bridge (AHB), which carries a major motorway.

The NAaN cable project comprises the yellow section in Figure 1. The 36.5km long cable route is challenging for the management of cable thermo-mechanical forces. It involves large conductor sizes (Table 1), duct and tunnel sections, major bridge crossings and earthquake design requirements.

Table 1. Installation Sections and Cable Types

| Installation Section | | | Cable Types | | |
|---|---|---|---|---|---|
| N° | Type | L km | Conductor mm² | Sheath | Type* |
| 1 | Duct | 8.4 | 2500 | CAS | 1 X |
| 2a | Duct | 5.9 | 2500 | CAS | 1 X |
| 2b | Bridge | 1.35 | 1600 | APL | 2 X |
| 2c | Duct | 2.4 | 2500 | CAS | 1 X |
| 3 | Tunnel | 9.4 | 2500 | APL | 3 Y |
| 4 | Duct | 9 | 2500 | CAS | 4 Y |
| Total: | | 36.5 | | | |
| CAS: welded corrugated aluminium sheath | | | | | |
| APL: aluminium plastic laminate sheath | | | | | |
| * cable suppliers: X and Y | | | | | |

Transpower required the largest current rating for the cable circuits reasonably achievable. Table 2 gives the power and current ratings by Section. 2500mm² enamelled copper conductors were specified for the in-ground Sections 1, 2a, 2c and 4 and deep tunnel Section 3. Section 2b on the Auckland Harbour Bridge was a complete drum length with no joints (1,350m) and as it was installed in air the smaller and lighter 1600mm² enamelled copper conductor achieved the same current rating.

Table 2: Continuously Loaded Winter Ratings

| Section and Cable | | | Rating | |
|---|---|---|---|---|
| No | Type | Conductor mm² | MVA | A |
| 1 | Duct | 2500 | 602 | 1580 |
| 2a | Duct | 2500 | 602 | |
| 2b | Bridge | 1600 | | 1580 |
| 2c | Duct | 2500 | | |
| 3 | Tunnel | 2500 | 781 | 2050 |
| 4 | Duct | 2500 | 735 | 1930 |

In 2001, Transpower and the local utilities started the development of a transmission corridor through the centre of the city, connecting Penrose Substation in the south to Albany Substation in the north. Together with an existing overhead line this would create a 220kV ring around Auckland City, Figure 1, and provide the opportunity for diverse supply routes to the major load centres.

A need was also identified to reinforce the transmission system into Auckland from the south. The North Island