A Real Root Pile (Pali Radici)
Support of Vancouver’s Hollow Tree
Parallels to Wind Turbine Foundations

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One of Vancouver’s famous landmarks, the over 1000 year old Hollow Tree in Stanley Park was and still is a unique gathering place where, for generations, people from all over the world have been photographed.
The North Western part of the park was devastated by a severe hurricane force wind which fell over 3000 trees and dangerously tilted the tree.
The tree was condemned to be taken down after it was tilting into a dangerous position of tipping over.
Two proposals were considered by the Vancouver Parks Board

• 1. Keep the tree standing with external braces.
• 2. Take the tree down and replace it with a replicate out of plastic.

Both proposals were criticized by the public.
Our proposal to keep the tree standing with a new (artificial) root system using Micro Piles as Root Piles, (as a donation to the city of Vancouver), was eventually accepted by the Parks Board.
Limited access and stringent environmental restrictions prohibited large equipment brought into the park, this opened the opportunity to suggest the use of Titan-IBO Micro Piles. The project was done in four stages.
First Stage

Straightening of the tree.
Braces with a hydraulic jacking system were used to push the tree to its original vertical position.
Second Stage

Installation of Micro Piles

15 Titan Hollow Bar Micro Piles (Root Piles)

8 inside and 7 outside the tree
IBO (Injection Boring) Titan Micro Piles (Root Piles) installed with a hand held Drill inside the hollow tree
Exposed Piles
Notice good grout cover
Before placing Pile Cap Concrete
Reinforcing Pile Cap
Root Piles after straightening of the Tree
Third Stage

Connecting the tree to the Micro Piles
1. ENGINEER TO VISIT SITE TO SELECT ACTUAL STAVE BAND LOCATION

2. TREE INSIDE SURFACE TO BE SCARRDED AT SELECTED LOCATIONS AND TEMPLATED FITTED TO TREE

3. FINAL LOCATIONS OF EPOXY EMBEDDED STUDS TO BE MARKED ON TEMPLATE AND PHOTOGRAPHIC EVIDENCE FORWARDED TO ENGINEER FOR REVIEW PRIOR TO STAVE BAND FABRICATION

4. WHERE POSSIBLE EXISTING BRACING AND REINFORCEMENT TO REMAIN IN PLACE UNTIL STAVE BANDS ARE INSTALLED AND EPOXY IS SET

5. REMOVE TREE MATERIAL BELOW GRADE ONLY TO FACILITATE INSTALLATION MEGEO FILLS AND TALL CAP REBAR

6. EXCAVATE AND REPLACE EXISTING EARTH WITH CLEAN TREE DRAINING UNIFORM HILL AFTER STAVE BAND INSTALLATION IS COMPLETE

7. AS MUCH AS POSSIBLE MAINTAIN EXISTING TREE ROOTS DURING EXCAVATION.
Three internal tubes forming a tri-pod
1/8" steel gusset plate welded to back and both cross braces.

Both cross braces welded to tubes along top and visible vertical edges.
The tree now connected to the Root Piles before the landscaping
Fourth Stage

Placing a Cap on the Hollow Tree to extend its life time
The Vision
Became the Reality
The group which made it happen
He approves
The Root Pile Support Paralleling to Wind Turbine Foundations?
Example:
Catastrophic failure of several wind turbine foundations near Vechta/ Lower Saxony, Germany

Here it was too late.

With a post-tensioned ground anchor system (or Root Piles), this type of failure could be avoided.
Conventional Spread Footing with Mass Concrete

Similar to the ones which failed in Germany

500 to 600 cubic yards of concrete are required
Source: Morgan, K., Ntambakwa, E., Garrad Hassan America, Inc., Wind Turbine Foundation Behavior and Design Considerations, AWEA Windpower Conference, Houston, June 2008
The Solution:
Alternative Foundation Systems with Micro Piles, Post-Tensioned Ground Anchors, and New Groutable Void Form (GVF) Technology
Deep Foundation Post-Tensioned Ground Anchors use ground mass to resist the overturning moment.

The foundation is pre-tested to its design loads and higher.
Only small equipment is required and the amount of concrete is largely reduced
Types of Tendons used for Post-Tensioning Wind Turbine Foundation Ground Anchors

- 7 Wire strand anchors 270 ksi low relaxation
- Solid bars 150 ksi for post-tensioning
- Injection Bore Anchor, hollow bar system
The Key to Post-Tension and Testing Wind Turbine Foundations Is The Groutable Void Form (GVF) Concept (patent pending)
Wind Turbine Foundation with Post-Tensioned Ground Anchors using Groutable Void Form (GVF)
Groutable Void Form

- Void between ground anchor and foundation cap filled with cement grout after tensioning.
CTS Groutable Void Form

Hard Plastic or sheet metal shell

Barbed fittings for grout tube
CON-TECH GROUTABLE VOID FORM FOUNDATION
FOUNDATION FOR WIND TURBINE GENERATOR SYSTEM

DESIGNED CRITERIA:

1. Fz (VERTICAL LOAD)=594,000 lb [2640 kN]
2. Fx (HORIZONTAL LOAD)=150,059 lb [660 kN]
3. M (MAXIMUM MOMENT)=34,758 ft-k [47,125 in-lb]
4. SEISMIC LOAD DOES NOT GOVERN, 2009 INTERNATIONAL BUILDING CODE.

SITE MAP LOCATION

FOUNDATION FOR WIND TURBINE
SCALE: 1"=50' 0"

3-D ISOMETRIC VIEW

FOUNDATION for a present project in Canada
Conclusions

• Over 75% reduction in foundation area
• Over 40% reduction in concrete consumption
• Over 70% reduction in reinforcing steel consumption
• 20% to 30% preliminary estimated total foundation cost reduction
• Pre-tested foundation in tension and compression to design loads or higher
Thank you