

TRANSMISSION **TOWERS IN BRAZIL**

A Case History: Helical Piles & Guy Anchors



10,000 TOWERS

The Rio Madeira Project in Brazil

One of the largest power lines in the world is being built in Brazil and Chance® helical piles and guy anchors made by Hubbell Power Systems, Inc. (HPS) are helping support the transmission towers in a diverse array of terrains and soil conditions.

Brazil's demand for electricity is growing by about 4.5% per year. That means by 2021, overall demand will rise from today's load of 472,000 GWh to a whopping 736,000 GWh—a 56% increase.

To meet this demand, the Brazilian government is building or plans to build as many as 48 new power plants over the next 10 years. Brazil is crisscrossed by rivers and all 48 plants will be hydroelectric with a combined generating capacity of 42,157 MW of power. Most of that (80%) will be generated by 18 new dams in the Amazon River Basin.

Two are already built. The Jirau dam produces 6.5 GW and Santo Antonio dam produces 6.3 GW of power. Both are in the Port Velho area.

There is just one problem.

In Brazil, the power-hungry East and Southeast is separated from the massive hydro generating plants in the Northwest by 1,475 miles (2,375 kilometers) of rugged terrain and smaller rivers. So, in addition to building new power plants, Brazil is also in a frenzy of transmission line construction. One of the largest ventures, the Rio Madeira Project, is currently under construction.

Build the Largest in Brazil

Being built by a consortium of companies, the Rio Madeira Project consists of two 600 kV DC transmission lines.

When finished, it will be the largest transmission line in Brazil and one of the largest in the world.

The Project will cross five Brazilian states, be supported by 10,000 towers and have approximately 47,200 miles (76,000 km) of conductor (ACSR 40/25mm). The two lines will transmit 12.8 GW of power 1,475 miles (2,375 km) from Port Velho to São Paulo.

Work on the first line began in 2011 and is nearing completion. Work on the second, parallel line started in middle of 2012 and should be completed in 2013. It will take 6,500 workers to finish and will cost approximately \$1.8 billion USD (about \$3.5 billion Reais).

The first line is owned by three companies: IE Madeira--formed by CTEEP (51%), Furnas (24.5%), Chesf (24.5%). The second will be owned by: NBTE--formed by Abengoa (51%), Eletrosul (24.5%), Eletronorte (24.5%).

Three companies are building the lines: Alta Energia (33%), Schahin (34%) and Toshiba (33%).



Support for all Terrains

Terrain and soil conditions vary greatly over the course of the line. As a result, tower designs vary: About 80% are single pivot, guyed towers, supported by helical anchors. About 20% are self-supporting (four legged) towers. The type of tower chosen for each location depended on geography (soil conditions) and line route (curves).

Some towers are in very remote locations making construction access difficult. When possible, center pivot, guyed towers were used, which lend themselves to the use of helical anchors.

There are three manufacturers in Brazil that produce helical anchors, but in lower quantities than HPS produces Chance® anchors. In February 2011, representatives of HPS Delmar facility in Brazil met with Alta Energia and Schahin.

Delmar is an HPS factory and distribution point for such products as arresters, cutouts and substation switches. The plant is located in Tatui, São Paulo. Delmar has been in business for more than 40 years and was acquired by HPS in 2005.

HPS suggested the tower-foundation contractors consider Chance® helical piles as an option and provided samples for testing along with quality reports and test results (including torsional loads). The contractors installed the sample helical piles down and performed compression and tension tests. They also contacted for reference other companies using Chance helical piles.

Between Schahin Engenharia and Alta Energia, both tension (SS200-square shaft) and compression (RS3500 round shaft for self support tower) were performed in Brazil under the supervision of HPS engineers.



Some tower locations were very remote and a challenge to access.

Fully satisfied, the contractors placed their first order in August 2011. Of the helical piles used on the first line, 50% are Chance® brand. The first line of the Rio Madeira project has 4300 towers. Of that, 3440 are guyed towers, with 1800 supported by Chance SS200 helical piles. Of 860 self-supporting towers, 250 are supported by Chance RS3500 helical piles.

Advantages Add Up

Brazilian utilities and contractors have been using concrete, driven-pile and precast tower foundations for several years. While technically efficient, these approaches have some disadvantages.

Comparison of Foundation Types

CONCRETE/PRECAST/DRIVEN PILE

- Requires a lot of cement
- Requires a lot of water
- Requires large earth moving equipment
- Requires large workforce
- Significant vibration (Driven Pile)
- Large impact on environment
- Difficult to install in some weather conditions

HELICAL PILE

- Requires no cement
- Requires no water
- Requires small tractor or backhoe with drive head
- Requires small workforce
- No vibration
- Very little impact on environment
- Can be installed in any weather conditions.

Since most of the towers are in remote locations, helical piles worked very well, and can be used in diverse soil conditions. Very sandy soil at some sites along the route would impede the installation of concrete foundations. Holes dug in sandy soil tends to cave in and require not only shoring but larger mass. Transportation obstacles to other sites would have impaired delivery of concrete and all its related equipment. These problems were overcome by helical piles, requiring one relatively small installation machine and fewer workers. This resulted in significantly lower total labor costs to install helical piles compared to a large concrete foundation for a single tower.



Extension rods allow the drive head to drill the helical piles deeply into the ground, until the proper torque is reached.



Helical foundations are easier and faster to install than traditional, concrete foundations. They also require significantly less material and far fewer workers.

Testing and Confidence

After installation, the contractors tested the majority of the helical piles. On the four legged towers that rest on helical piles, the contractors tested one of the five to seven piles for each leg. On the center pivot towers, the contractors tested every guyed foundation.

Testing was necessary for two reasons. First, the Brazilian government required it as part of the construction contract. Second, this was the first time the contractors had worked with this type of foundation system and they wanted to confirm the piles would work in the various soil conditions.

Testing did reveal a few problems that illustrate the importance of having accurate soil information. At some sites, soil conditions were deceiving. At one such location, a helical pile had been installed to the correct torque resistance, but testing pulled it out. To remedy that, the contractor simply installed the helical pile deeper. At another site, subterranean cavities forced the engineers to abandon a center pivot design and put in a self-supporting tower due to those soil conditions.

All problems were resolved by correcting testing procedures, changing the tower design or readjusting drilling depths (torque).

Circuitous Delivery Route

HPS manufactures Chance® helical piles in Centralia, Missouri, but the product needed to go to the wilds of Brazil. This required an interesting materials delivery route.

First packed in crates in Missouri, the helical piles then shipped to a US port and by sea to Santos, the largest port in Brazil. From there, shipments were delivered by trucks over the 150 miles (240 km) to the HPS Delmar facility. From there, the materials were transported to staging areas and construction sites across Brazil — including some destinations as far as 1,800 miles (3,000 km).

There were no shipping or delivery problems. Everything arrived on time. Orders were placed well in advance, so HPS could plan manufacturing and transportation. At first, sources in Brazil made deliveries sooner than HPS. By the end of the project, Chance® helical piles were delivered ahead of schedule and faster than those of local competitors.

This high level of service and product performance bodes well for future projects to employ Chance® helical piles and guy anchors. Their value as a solution for difficult site and soil conditions was well received.



Extensive testing was done on the helical piles, including tension tests.



Contractors also ran compression tests.

The international and interpersonal experience of this iconic undertaking established strong ties between all parties involved. Those relationships formed a working foundation certain to continue building in concert with Brazil's next power line ventures.



Square Shaft guy anchors deliver for heavy loads in tough soils

Load capacities to 200,000 lb. Torque capacities to 20,000 ft-lb.

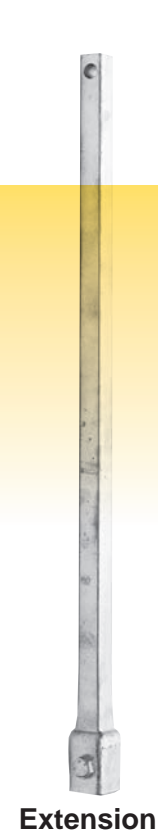
Five performance sizes are suited to a wide range of soil conditions.

Chance® helical guying anchors and foundation piles work together to provide adequate lateral support and resistance to overturning moments.

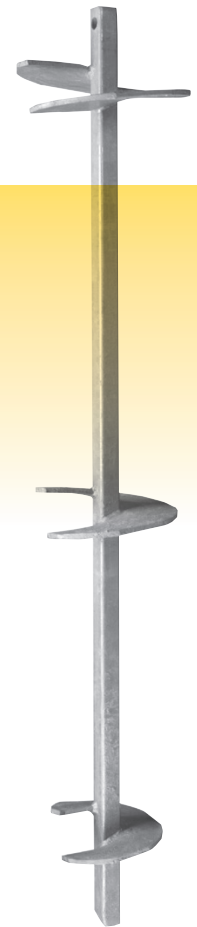
- Draw on our 100 years of anchoring leadership in the industry
- Call on us for our expert anchor-engineering application support
- Utilize our copyrighted HeliCAP® Helical Capacity Design Software
- Get our unmatched manufacturing capacity, capability and in-stock inventory



Guy Adapter



Extension



Lead Section

CHANCE® Square Shaft (SS) Helical Product Ratings

Product Series	Torque Rating ft-lbs (Nm)	Ultimate Tension Strength* kip (kN)	Uplift/Compression Capacity Limit** kip (kN)
SS5	5,500 (7 500)	70 (312)	55 (245)
SS150	7,000 (9 500)	70 (312)	70 (312)
SS175	10,500 (14 200)	100 (445)	110 (489)
SS200	16,000 (21 700)	150 (668)	150 (668) ***
SS225	23,000 (31 200)	200 (890)	200 (890) ***

* Based on Mechanical Strength of Coupling

** Based on Torque Rating – Uplift/Compression Capacity Limit = Torque Rating x Kt.

"Default" Kt for Type SS = 10 ft-1 (33 m-1)

*** Based on Mechanical Strength of Coupling Bolt

Higher Compression Capacities Available with Helical Pulldown® Micropile



Instant Foundation® helical piles
go places concrete piers cannot

Soil and load-matched capacities: Any load. Anywhere.

To match a wide range of site conditions, Chance® foundations include single-piece and extendable designs.

Helix plates of mill-specified high-strength steel distribute the up-lift and compression forces.

The central shaft transfers horizontal shear, torsion and bending loads to surrounding soils.

Properly selected helical-pile foundation groups can support virtually any transmission structure loads in any soil conditions.



CHANCE® Round Shaft (RS) Helical Product Ratings

Product Series	Torque Rating ft-lbs (Nm)	Ultimate Tension Strength* kip (kN)	Uplift/Compression Capacity Limit** kip (kN)
RS2875.203	5,500 (7 500)	60 (267)	49.5 (220)
RS2875.276	8,000 (10 846)	90 (400)	72 (320)
RS3500.300	13,000 (17 600)	120 (534)	91 (405)
RS4500.337	23,000 (31 200)	140 (623)	138 (614)
RS6625.280	40,000 (54 233)	200 (890)	200 (890)
RS8625.250	60,000 (81 349)	300 (1 334)	300 (1 334)

* Based on Mechanical Strength of Coupling

** Based on Torque Rating – Uplift/Compression Capacity Limit = Torque Rating x K_t

“Default” K_t for Type RS2875 Series = 9 ft⁻¹ (30 m⁻¹); for Type RS3500.300 = 7 ft⁻¹ (23 m⁻¹);

for Type RS4500.337 = 6 ft⁻¹ (20 m⁻¹);

for Type RS6625.280 = 5 ft⁻¹ (13 m⁻¹);

for Type RS8625.250 = 4 ft⁻¹ (13 m⁻¹);

About Hubbell Power Systems

Hubbell Power Systems (HPS) manufactures a wide variety of transmission, distribution, substation, OEM and telecommunications products used by utilities. HPS products are also used in the civil construction, transportation, gas and water industries. Our product line includes construction and switching products, tools, insulators, arresters, pole line hardware, cable accessories, test equipment, transformer bushings and polymer precast enclosures and equipment pads.

Preprinted for a 2013 issue
of Hubbell



Hubbell has a policy of continuous product improvement. We reserve the right to change design and specifications without notice.

©Copyright 2013 Hubbell Incorporated
Printed in U.S.A.

CH06004E

www.hubbellpowersystems.com

