



Earth Systems Global, Inc.

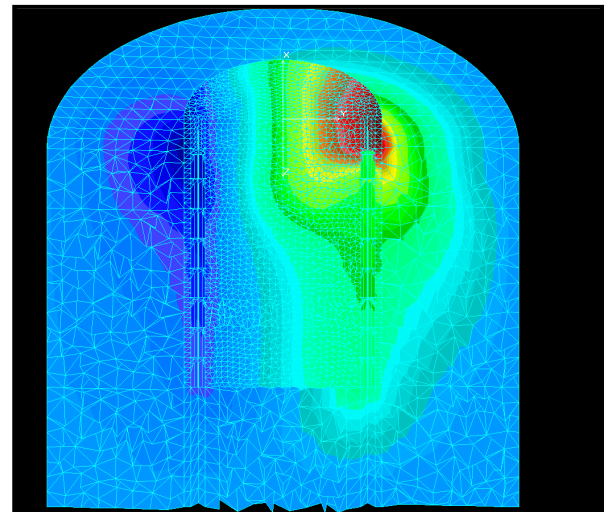
Engineering for the future

P&H Foundations for Wind Turbine Support

P&H Tensionless Pier



P&H Rock or Pile Anchor Foundation



Did you know?

🌀 P&H foundations are the most economical available for wind turbine support.

- 20% to 35% less than the cost of a gravity spread foundation
- About 3 to 6% savings in total project development costs

🌀 P&H foundations are the most environmentally green.

- The smallest footprint available, with far less ground disturbance than a gravity spread foundation.
- Uses far less total concrete and steel than a gravity spread foundation with much quicker assembly:
 - 50 to 75% reduction in concrete
 - 40 to 55% reduction in steel

Fewer materials make the P&H foundations a more attractive ecological and environmental solution for foundation support.

🌀 P&H tensionless pier foundations are the only GL certified foundations in North America.

We can offer site-specific GL certification for our foundations, a unique advantage.



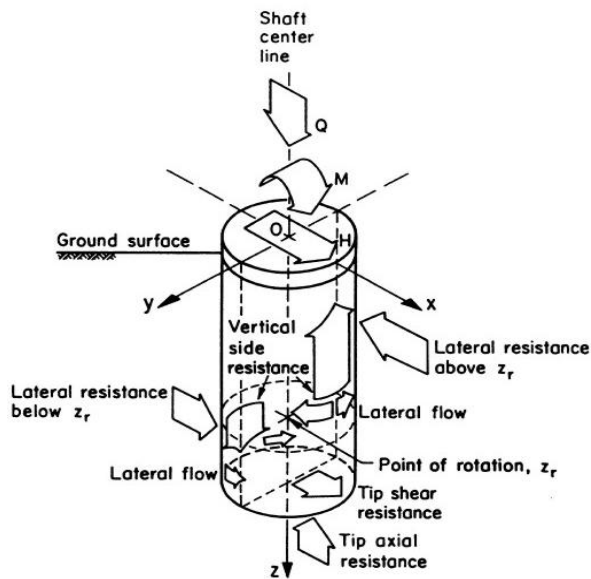
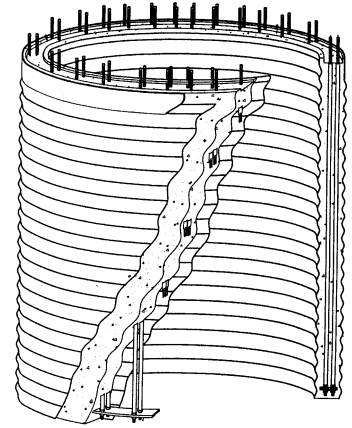
- 🌀 P&H foundations are adaptable to the poorest of ground conditions and can support turbines over landfills and mine spoils.
- 🌀 P&H foundations have a proven track record of about 5200 foundations installed supporting about 6500 MW of wind turbine capacity.
- 🌀 P&H foundations have a demonstrated performance record with tower frequency requirements. Anchor foundations are fully load tested to factored extreme loads.
- 🌀 P&H tensionless pier foundations are supporting the largest wind turbines to date in North America, the Vestas V-90 on 105 meter towers in Snyder, Texas.
- 🌀 With these facts,

- ***Why consider anything else to support today's wind turbines?***
- ***Other foundations types are a costly and unnecessary consumption of valuable resources of cement and steel.***

P&H Tensionless Pier

The Patrick and Henderson Tensionless Pier (P&H pier) is a patented, proprietary foundation to support wind turbines on monopole towers. The foundation consists of a large diameter, cast-in-place annular pier (typically 14 to 16-feet in diameter and 25 to 35-feet deep).

Corrugated metal pipes (CMP) provide a stay in place form for the interior and exterior of the concrete annular pier. The hollow interior of the P&H pier is normally backfilled with a three-foot thick concrete plug at the base, followed by uncompacted soils (comprised of spoil from the foundation excavation process), and a 12-inch thick structural slab across the top of the annular. The embedded depth of the P&H pier varies depending on the applied loading from the wind turbine and subsurface conditions at the site. The anchor bolts of the wind turbine tower are post-tensioned to ensure that the concrete that comprises the pier remains in compression, even when subjected to extreme wind loading.



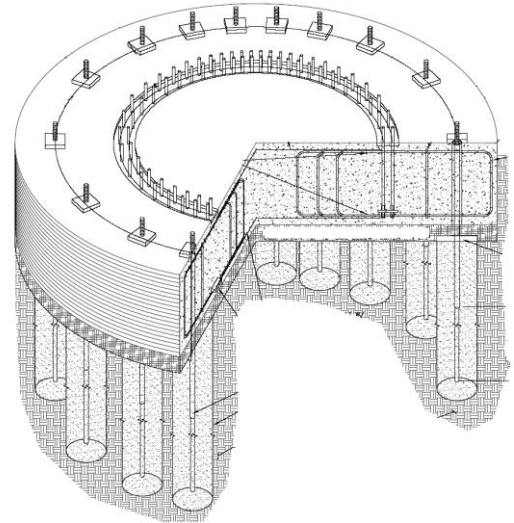
The P&H pier differs from a conventional gravity spread foundation often used for support of wind turbines in the way the foundation loads are transferred to and resisted by the supporting soil materials. In a conventional spread footing, the vertical loads and overturning moments applied at the top of the foundation are resisted by the weight of the spread footing and bearing on the base of the foundation, and the horizontal loads are resisted by friction at the base of the spread footing. However, the P&H pier resists the applied horizontal loads and overturning moment mainly by horizontal resistance of the soil that surrounds the annular pier and to a much lesser extent by bearing on the base of the pier.



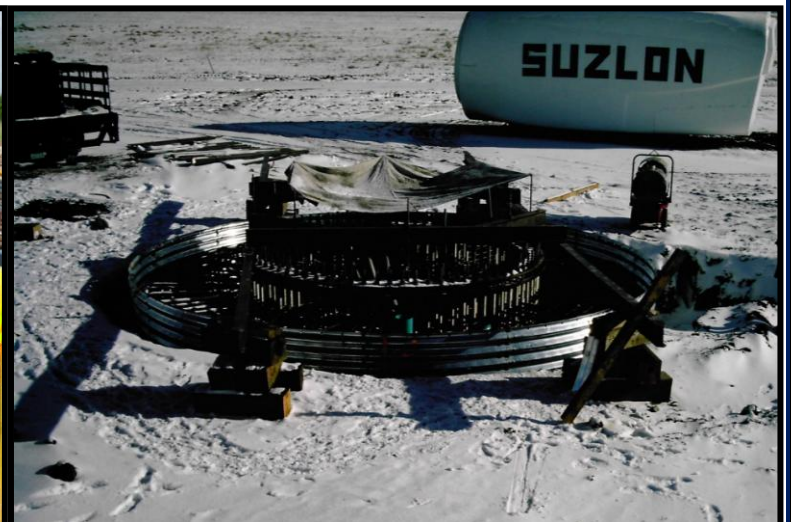
P&H Rock or Pile Anchor Foundation

The Patrick and Henderson (P&H) rock or pile anchor foundation is a proprietary (patent pending) foundation used to support large wind turbines. The P&H anchor foundations consist of a 5-foot thick, 24-foot diameter, reinforced concrete mat (cap) supported by commonly 12 to 20, 35 to 50-foot long anchors aligned within a typical 20-foot diameter circle. Large wind turbines greater than 2 MW may require more anchors and a double row.

Large 2-½ inch diameter rods are used as the anchors. The number and length of anchors are based on the magnitude of applied loads at the top of the foundation as well as the soil and rock conditions. The pile or rock anchors are installed by drilling a shaft and the anchor rod is inserted and grouted. Post-tensioning is used to develop an internal tension force in each anchor. The intention is to have enough tension in the rod to reduce foundation deflections from normal wind loading.



The large overturning moments induced by the wind turbine are resisted by friction (bond stress) along the length of the anchors. The anchors are post-tensioned to create a compression stress on the subgrade beneath the cap. The post-tension load resists the overturning moment by creating a built-in clamping force to keep the cap in place. The higher the pre-tensioning of the anchors results in a higher moment capacity of the foundation. The post-tension load in the anchor is calculated to cover the load imposed by maximum wind forces given by the turbine manufacturer. Normal operational loads do not produce stress reversals in the subgrade/concrete interface or the anchor so there is no substantial fatigue or cyclic degradation of the soil or rock.



Engineering for the future



Earth Systems Global, Inc.

Committed to the advancement of renewable energy development, Earth Systems has provided services for over 130 utility-scale wind energy sites throughout the United States and Canada, and in Cuba, Jamaica, and China.

Our services provided for renewable energy projects include:

- ☛ **Preliminary Site Assessments and Feasibility Reports**
- ☛ **Geotechnical Engineering Investigations**
- ☛ **Geologic and Seismic Hazard Studies**
- ☛ **Geophysical Exploration including seismic refraction/ReMi, and soil resistivity**
- ☛ **Engineering Design of Foundations**
- ☛ **Testing and Inspection: pile load testing and inspection of foundations and concrete**

WIND

Earth Systems provides engineering design for the P&H tensionless pier, rock and pile anchor foundations, and deep gravity spread foundations. These innovative and economical foundation designs enable support of wind turbines in otherwise unsuitable ground such as reclaimed land from coal mine spoils and landfills, thus enhancing the environmental benefits of wind energy. They also use less concrete and less materials for construction. Supporting turbines of up to 3-megawatts and monopole towers of up to 105-meters, P&H foundations have been used for about 5200 turbines, representing a rated production of 6200 megawatts of energy.

The following pages feature some of our representative wind energy projects.



SOLAR

Earth Systems provides a unique set of services to the solar energy industry. Our skills in geotechnical engineering, geology, geophysics, and testing and inspection answer to the needs of the dynamic nature of solar power generation. We understand the challenges presented by project timing requirements, site access restrictions, and environmental and ecological considerations.

In response to accelerated project schedules often associated with solar energy development, our professionals are experienced in completing our services promptly and expeditiously. For projects that are located at remote sites and that are environmentally sensitive, select services can be performed without the need of motor vehicles, using only foot traffic and thereby incurring less impact to the site. Routinely, we interact with specialists such as cultural monitors and biologists to promote the preservation of on-site wildlife and vegetation.

GEOHERMAL

Earth Systems employs Professional Geologists, Professional Geophysicists, Engineering Geologists, and Hydrogeologists who have extensive experience providing consultation and assistance for the assessment and development of geothermal resources.

HULL II WIND ENERGY PROJECT Massachusetts



Constructed over 67 feet of landfill, the Hull II Wind Energy Project includes a Vestas V-80 1.8-megawatt turbine on an 80-meter tower. The tower is supported on a P&H pile anchor foundation. Two rows of piles were driven to dense rock and rock anchors were extended below. This project was featured at 2006 AWEA Conference for its innovation. Earth Systems provided engineering design support for the project.



Piles and Rock Anchor Bolts

BUFFALO MOUNTAIN WIND ENERGY PROJECT Anderson County, Tennessee



A Tennessee Valley Authority project, the Buffalo Mountain Wind Energy Project consists of 15 towers 80-meters high supporting Vestas V80 1.8-megawatt turbines.

The unique aspect of this project is that the foundations are on reclaimed land from coal mine spoils.

P&H tensionless pier foundations were used for the support of the towers, and Earth Systems provided engineering design support.

SNYDER WIND ENERGY PROJECT Scurry County, Texas



With towers reaching 105 meters high, the Snyder Wind Energy Project's wind turbines are the tallest in the United States to date. (**Maximum Height to Blade Tip = 150 m, 492 feet!**) The project comprises 21 Vestas V90 3.0-megawatt wind turbines. Earth Systems provided engineering design support for the P&H tensionless pier foundations, which extended 40-feet deep into hard clay and sandstone, using an Anderson Drilling "Big Stan" 18-foot diameter auger rig.

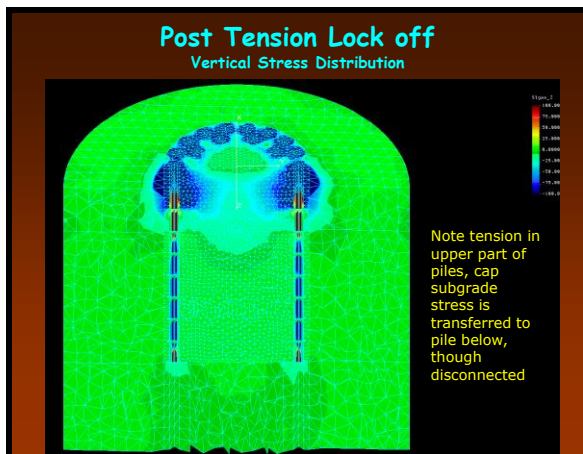


Wind Energy Projects with P&H Rock / Pile Anchor Foundations

Year Built	Project	Location	Turbine Type	Tower Height (m)	No.	Total MW
2004	Guantanamo Bay US Naval Base	Cuba	NEG-Micon 950 kW	55	4	3.8
2006	Hull 2	Hull, MA	Vestas V-80 1.8 MW	80	1	1.8
2006	Forest Creek	Big Spring, TX	Siemens 2.3MW	80	54	124.2
2006	Sand Bluff	Big Spring, TX	Gamesa G87 2.0MW	78	45	90.0
2006	Locust Ridge	Mahonoy City, PA	Gamesa G87 2.0MW	78	13	26.0
2006	Mars Hill	Mars Hill, ME	GE 1.5MW	80	28	42.0
2008	Mountain Home	Mountain Home, ID	Suzlon S-88-2.1 MW	79	20	42.0
2008	Wray	Wray, CO	Directwind 54 900kW	38	1	1.0
2008	Stetson Mountain	Danforth, ME	GE 1.5MW	80	38	57.0
2008	Kent Hills	Kent Hills, NB	Vestas V-90 3.0 MW	80	32	96.0
2008	Locust Ridge II	Mahonoy City, PA	Gamesa G87 2.0MW	78	53	106.0
2008	Pine Tree Wind	Mojave, CA	GE Wind 1.5 MW	65	80	120.0
2008	Lempster Wind Farm	Lempster, NH	Gamesa G87 2.0MW	78	12	24.0
2008	Portsmouth	Portsmouth, RI	AAER 1500-77 1.5 MW	65	1	1.5
2008	Tin City	Tin City, AK	Vestas V27 225 kW	31	1	0.2
2008	Mark Richey Woodworking	Newburyport, MA	Vestas RRB 600 kW	65	1	0.6
UC	Kibby Wind Power	Franklin County, ME	Vestas V-90 3.0 MW	80	44	132.0
TOTAL					428	868



From Finite Element Analyses to Anchor Tensioning & Load Testing to Verify Performance



LISTING OF SELECTED WIND ENERGY PROJECTS ON P&H PIER FOUNDATIONS:

HORSE HOLLOW II, ABILENE, TEXAS 128 towers measuring 80-meters each with Siemens 2.3-megawatt turbines

WILDHORSE, KITTITAS COUNTY, VANTAGE, WASHINGTON 127 towers measuring 67-meters with Vestas V-80 1.80-megawatt turbines

OASIS, MOJAVE, CALIFORNIA 60 towers measuring 60-meters with Mitsubishi MH1 1-megawatt turbines

WIGTON, JAMAICA 27 towers measuring 50-meters each with NEG-Micon 950 kilowatt turbines

MCBRIDE LAKE-FORT MACLEOD, PINCHER CREEK, ALBERTA, CANADA 114 towers measuring 50-meters each with Vestas V-47 660 kilowatt turbines

STATELINE, WALLA/UMATILLA COUNTIES, WASHINGTON AND OREGON 399 towers measuring 50-meters each with Vestas V-47 660 kilowatt turbines

KING MOUNTAIN, MCCAMEY, TEXAS 214 towers measuring 62-meters each with Bonus 1.3-megawatt turbines

GRAY COUNTY, MONTEZUMA, KANSAS 170 towers measuring 65-meters each with Vestas V-47 660 kilowatt turbines

WOODWARD RANCH, MCCAMEY, TEXAS 242 towers measuring 52 meters each with Vestas V-47 660 kilowatt turbines

P&H Foundations Built Supporting Wind Energy Projects





Earth Systems

group of companies

ES GEOTECHNOLOGIES

MILPITAS, CA | TEL: (408) 934-9302

EARTH SYSTEMS SOUTHWEST

BERMUDA DUNES, CA | TEL: (760) 345-1588

EARTH SYSTEMS GLOBAL, INC.

BERMUDA DUNES, CA | TEL: (760) 345-1588

EARTH SYSTEMS PACIFIC

SAN LUIS OBISPO, CA | TEL: (805) 544-3276

HOLLISTER, CA | TEL: (831) 637-2133

LOMPOC, CA | TEL: (805) 737-9755

SALINAS, CA | TEL: (831) 422-8547

SANTA MARIA, CA | TEL: (805) 928-2991

EARTH SYSTEMS SOUTHERN CALIFORNIA

PALMDALE, CA | TEL: (661) 948-7538

PASADENA, CA | TEL: (626) 356-0955

VAN NUYS, CA | TEL: (818) 901-8075

VENTURA, CA | TEL: (805) 642-6727

SANTA BARBARA, CA | TEL: (805) 966-9912

CORPORATE HEADQUARTERS

SAN LUIS OBISPO, CA | TEL: (805) 781-0112

Who we are and our mission

The Earth Systems group of companies is committed to providing quality professional services to our customers, and a safe and rewarding work environment for our employees. We strive to uphold our excellent reputation by continually improving our operations and methods, while sustaining the resources essential to engineer for the future.

The year 2009 marks our 40th year providing geoprofessional services. Our dedicated staff brings a wealth of experience and knowledge to the diverse geotechnical, geologic, environmental, and construction-related issues that may affect our clients' projects, with the aim of developing practical and economical solutions. As we reflect with pride on our history, we look ahead to the opportunities that abound for improving our world, pressing forward by engineering for the future.

With offices spanning the State of California, and a service area that includes much of the Western United States and beyond, the Earth Systems group of companies offers local knowledge of geotechnical conditions plus a broad base of professional and technical expertise

Experience and high professional standards characterize the work of Earth Systems. When a project requires geotechnical input, Earth Systems can provide proposals, recommendations and a full range of design and construction related services. Professional and technical services offered include:

- ⊕ Soil (Geotechnical) and Geologic Investigations
- ⊕ Seismic hazard and dynamic response studies
- ⊕ Fault location reports
- ⊕ Construction materials testing and evaluation
- ⊕ Construction observation
- ⊕ Phase I and Phase II Environmental Assessments
- ⊕ Site characterizations and remediation plans
- ⊕ Geophysical Studies
- ⊕ Forensic Studies
- ⊕ Percolation Testing

Earth Systems maintains constant client contact to ensure continuity from concept to project completion. Our reports are written to be informative to both the expert and layman. Thus, clients, governing agencies and the general public can comprehend their meaning.

Earth Systems has demonstrated its capabilities on a wide range of projects such as:

- Residential, commercial and industrial subdivisions
- High-rise hotels, apartments and offices
- Schools, hospitals and public buildings
- Wharfs, docks, breakwaters and shoreline erosion devices
- Airport facilities
- Electrical generation facilities
- Military facilities, Municipal facilities

Contact Us



Earth Systems

Global, Inc.

Shelton L. Stringer PE, GE, PG, EG
President / Geotechnical Engineer & Geologist

*Foundation Engineer for
Energy Projects*

79-811C Country Club Drive
Bermuda Dunes, CA 92203
(760) 345-1588

e-mail: sstringer@earthsys.com
On the web: www.earthsystems.com

1 (800) 924-7015
Fax: (760) 345-7315

◆ Geotechnical Engineering
◆ Geology

◆ Environmental Services
◆ Construction Testing

Mr. Stringer's email:
sstringer@earthsys.com

Associate:
Hongbin Huo, PhD, PE
hhuo@earthsys.com

Consultant:

Allan Henderson, PE, GE
Patrick and Henderson, Inc
1965 Airport Drive
Bakersfield, California 93308.
(661) 391-9854

phinc001@aol.com