

# RENEWABLE ENERGY | Patrick & Henderson Foundations



## Industry Challenges

More and more energy companies are looking for innovative, efficient, and ultimately, cost-effective ways to generate power. Terracon and its partners are uniquely qualified to help clients optimize energy project design and minimize risk, saving time and money.

We understand the challenges of foundation optimization. Engaging with our clients early in the feasibility process mitigates risk and ensures site compatibility, allowing you to make informed decisions in qualifying your renewable energy sites for further development.

## Experience and Expertise

There is a growing demand in wind energy generation to increase the size of wind turbines as well as the rotor diameter and tower height. With increasing material prices, the traditional gravity spread foundation design no longer provides a cost-effective solution for wind clients as it once did.

The Terracon team has developed an optimized foundation design which reduces the quantities of concrete and steel required to support larger turbines.



## Design Optimization

Terracon is the engineer of record for the Patrick & Henderson (P&H) Tensionless Pier, P&H Rock Anchor Foundation, P&H Soil Anchor Foundation which are alternatives to traditional gravity spread wind turbine generator (WTG) foundations. These options have various applicability based upon site soil and geologic conditions, but all provide construction costs savings between 25 and 50 percent depending on selected WTG technology and site-specific conditions. They also reduce risk related to seismic hazard, flood inundation, scour, and foundation fatigue, and can be re-certified for use in repowering projects.

Terracon is exclusively partnered with four companies: Patrick & Henderson, Inc., Structural Observations Services, Contech Engineered Solutions, and Williams Form Engineering Corp, to provide flexible, high quality, risk-reducing solutions much quicker than ever before.

Our foundation systems have received independent engineering approvals and/or certifications from Sargent & Lundy, DNV GL, and AWS Truepower,

providing you the confidence the P&H foundation systems not only stand up to structural stresses and fatigue, but are financeable as well. These approvals and certifications were achieved through state-of-the-art Finite Element Analysis and numerical modeling performed to support the selected design.

## Finite Element Analysis

Terracon performs Finite Element Analysis using Midas GTS NX software to model the P&H Foundation Systems. Our engineers can estimate the rotational and horizontal stiffness of the foundation; the total, vertical, and horizontal movements; and the stresses and strains in the foundation and surrounding soils to ensure there is no tension in the foundation system.

Additionally, we perform Geotechnical Numerical Modeling and Structural Fatigue Calculations to support the foundation system construction plan sets.



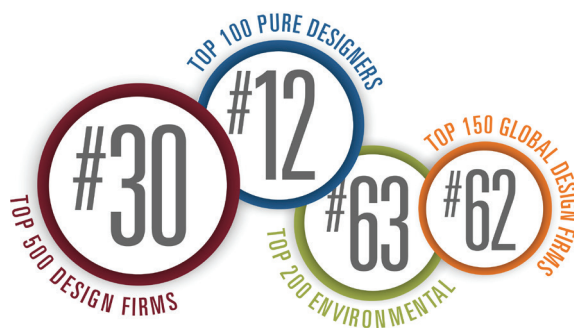
# WHY TERRACON?

**Resourceful.** Terracon applies new processes, methodologies, and techniques to solve project challenges cost effectively. Our innovative tools and resources enable us to customize an approach to efficiently mitigate and prevent risks.

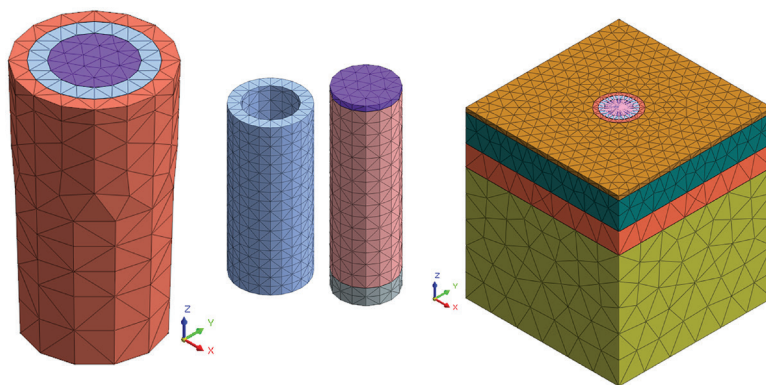
**Responsive.** Through our national network of offices, accredited laboratories, and exploration fleet, Terracon can act quickly to develop a customized approach to provide you the most cost-effective program to develop the right data for you.

**Reliable.** We deliver high-quality, expert soil and rock characterization using diverse exploration methods and software. This ensures the accurate and precise results you need to successfully mitigate risks.

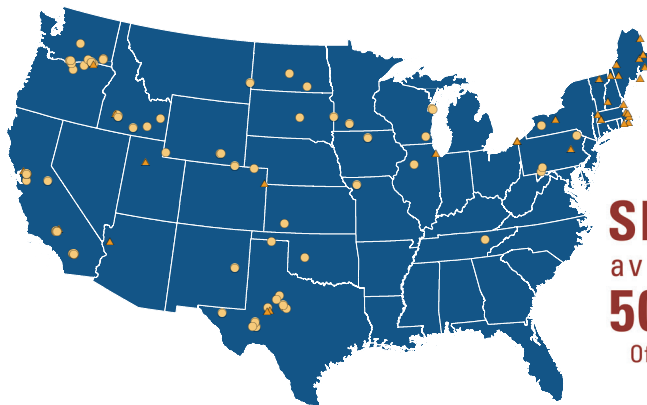
ENR Rankings | 2017



## COMPONENT VIEW OF FINITE ELEMENT MESH



## LOCATIONS OF VARIOUS INSTALLED FOUNDATIONS



**SERVICES**  
available in all  
**50 states**

Offices Nationwide

Legend  
Foundation Type  
▲ Anchor  
● Pier

# Terracon

### OUR TRUSTED PARTNERS

**CONTECH**  
ENGINEERED SOLUTIONS

**PATRICK &  
HENDERSON**  
INC.  
CIVIL & GEOTECHNICAL  
ENGINEERING

**Structural  
Observation  
Services**

**WILLIAMS**  
FORM ENGINEERING CORP.

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Environmental

Facilities

Geotechnical

Materials