

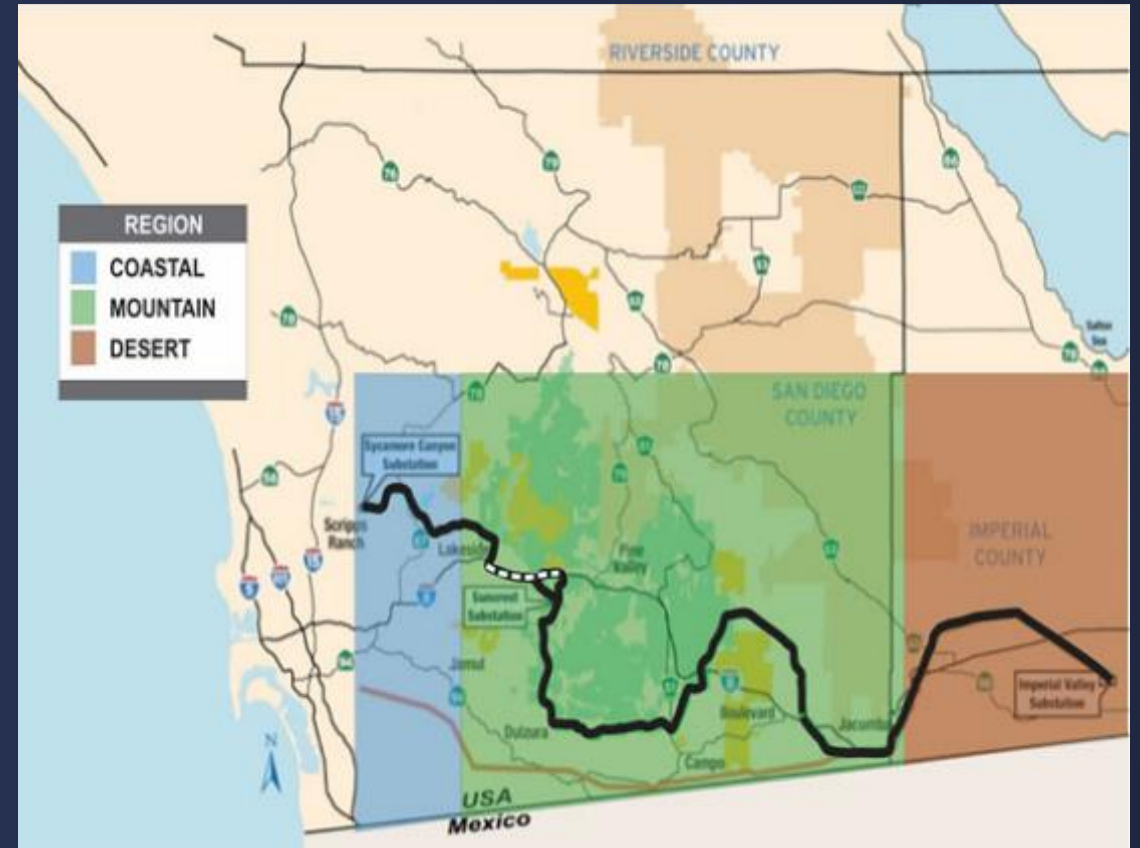


Sunrise Powerlink Project

North America World Cup Representative

Project Overview

- 188 km, 500 and 230 kV transmission line in southern California
- 421 total lattice tower structures
- Traverses Desert, Mountain and Marine environments
- Rugged, remote, environmentally sensitive terrain
- Capable of transporting over 1,000 MW of renewable energy into the San Diego metropolitan area



Challenges

- Protected Environments: National Forest Land and protected species habitat
- Restricted Road Access: 234 lattice tower sites identified as helicopter-only
- No Site-Specific Geotechnical Data due to pre-construction access constraints
- Wide Range of Geological Conditions
- Aggressive Construction Schedule: Required energization by June 2012



Selection of Micropiles

- Micropiles Selected for all helicopter-only sites
 - Componentized, portable equipment
 - Lightweight, high capacity materials
 - Adaptability to rugged terrain and steep slopes



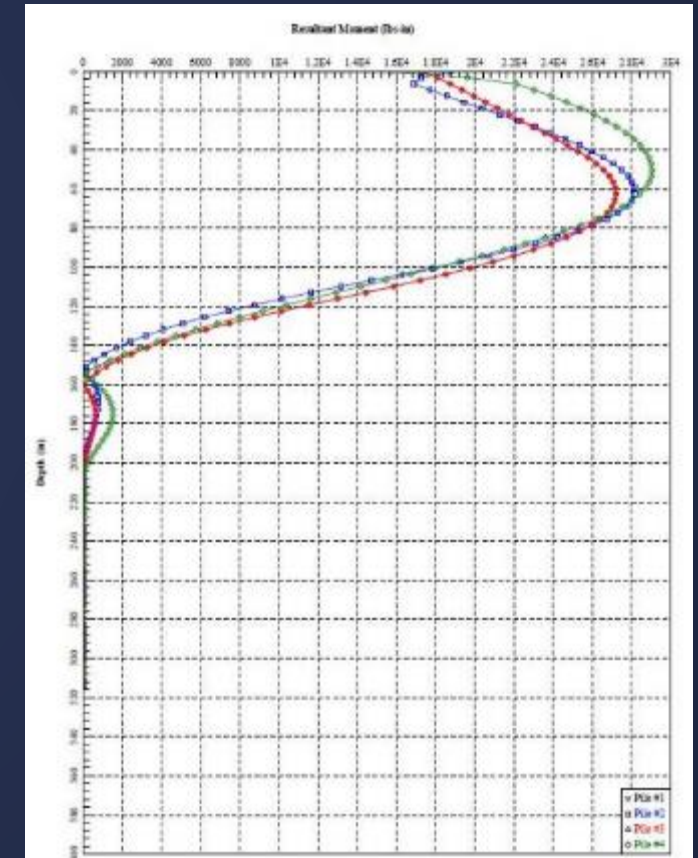
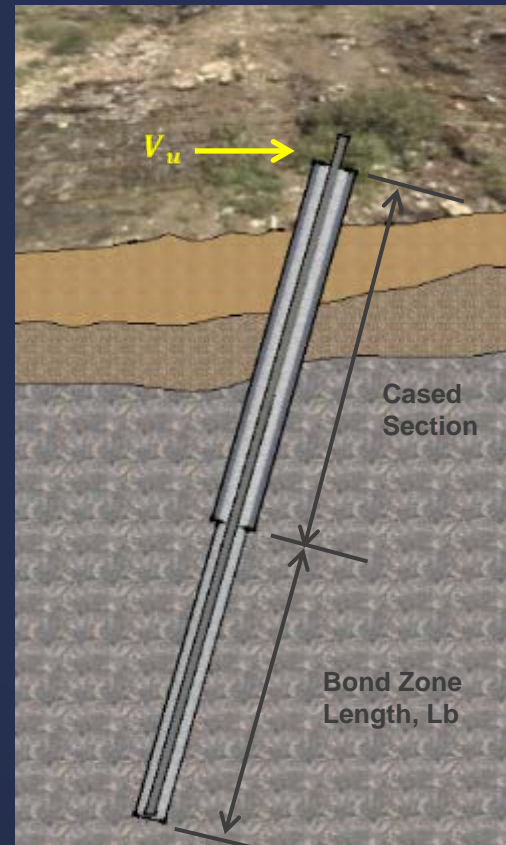
Introduction of Steel Pile Cap

- **Steel Pile Cap Design** introduced as an alternative to specified cast-in-place concrete
 - **Less Field Construction Time** would allow for increased schedule flexibility
 - Worked with the owner to define design and fabrication standards
- **Development of Design Requirements:**
 - Fasten to micropiles **without welding**
 - Bolted connections required to develop fixity with piles and **limit foundation deflections to 2.5 cm**
 - **Design life of 75 years** with no regularly scheduled maintenance



Lateral and Axial Analysis

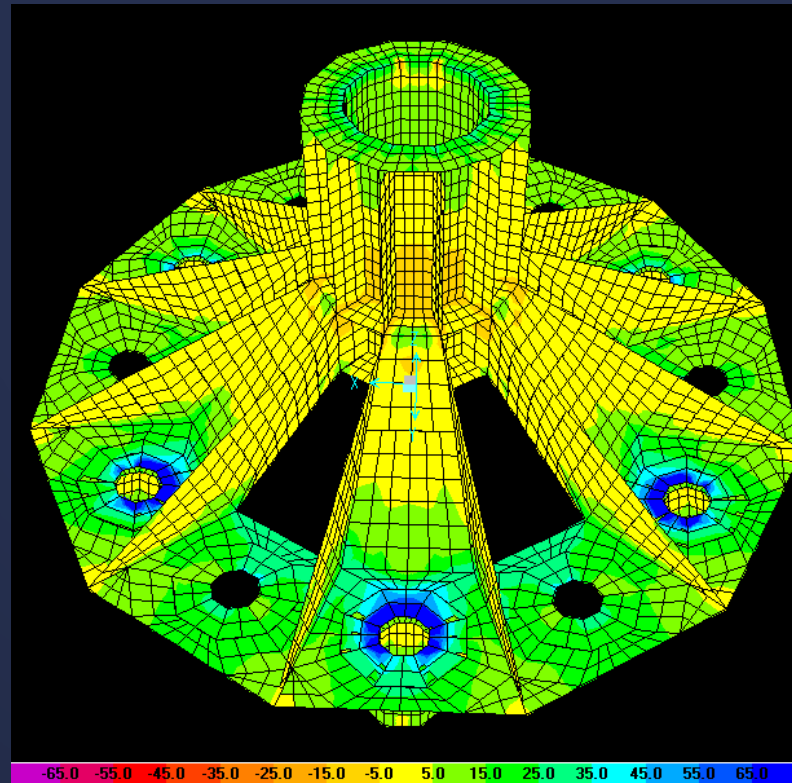
- Model battered pile group rather than individual piles for a range of geotechnical conditions



Design & Modeling of Steel Pile Cap

- Finite Element Modeling

- Utilized to more accurately predict stresses and deflections of complex steel shape
- **Total Cap Weight Reduced** through focused review of localized yielding/buckling potential



Validation of Steel Pile Cap Design

- Ultimate Load Test

- Two full-scale prototype caps fabricated and installed
- **4450 kN (1000 kips) of compression load and 1334 kN (300 kips) of lateral load simultaneously**
- Deflections measured to substantiate finite element predictions



Steel Cap Benefits

Reduction in Field Crew Hours

- Concrete Cap = 14 Hours
 - Steel cap = 5 Hours
- } 64% Reduction

Minimized Environmental Footprint

- Reduced Excavation
- Decreased Helicopter Emissions

Reduced Safety Risk

- Less Onsite Labor Time
- Fewer Helicopter Associated Activities

Increased Quality Assurance

- Caps Manufactured in a controlled facility
- Increased testability



Construction Sequence

1. Site Preparation
2. Set and Level Drill Deck
3. Set Drill Rig
4. Set remaining Ancillary Equipment and Materials
5. Advance Casing and Drill Open Hole (Type A Piles)
6. Set All-Thread Bars
7. Grout
8. Test 2 Piles
9. Pile Cap Installation



Project Chronology

- December 2010: Project Awarded
- February 2011: Expected Start Date
- April 2011: Limited NTP – 8 Structures in Desert Region
- August 2011: Limited NTP in Protected Species Habitat
- October 2011: First Milestone Completed – Protected Species Habitat
- December 2011: 60% Completed
- April 2012: Substantial Completion of Foundation Work
- June 2012: Sunrise Powerlink Energization



Summary



2013 Best Energy Project

2013 Best Geotechnical Engineering Project

American Society of Civil Engineers

2012 Best Civil Infrastructure Project

Engineering Excellence California

2013 **OUTSTANDING PROJECT AWARD**

2013 BIRMINGHAM **INNOVATION AWARD**

“The regulatory review completed for Sunrise is considered to be the **most comprehensive** study of a proposed transmission power line in state history.”

Transmission Distribution World

“A **complex and challenging** energy project that ranks among the largest and most significant in the history of San Diego Gas & Electric”