River Bank Foundation Design

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Objective and Basis

• Presentation of design and construction considerations for river bank and river crossing foundations on transmission line projects.

• Topics Covered
  • Loading
  • Structure Types
  • Design Process and Alternatives
  • Constructability and Construction Methodology

• Project Examples:
  • 2,700-foot crossing of Missouri River
  • Multiple crossings of Minnesota River
Examples - Foundations
Basic Foundation Design
Loading Factors

Significantly higher load due to wire selection (strength) and tension. Resulting ground line moments significantly higher.

Total loading may result in alternative designs.
Loading Considerations

• Guyed vs. self-supporting
• Deadend vs. tangent
• Required additions
  • Markings, lighting, maintenance, underbuild
• Geotechnical (soils/rock)
• Environmental concerns
  • Water flow, flooding, debris, wildlife
Pole Loads - General

- Conductor point loads
- Pole self-weight
- Wind loads
  - Wind on pole
  - Wind on wire
- Ice loads
- Hardware
- Maintenance/construction loads
  - Stringing loads
Conductor Resultant Load

- Conductor weight, ice, and wind combined
Structure Types

Monopoles
Structure Types

Multi-Pole Structures
Structure Types

Lattice Structures
Structure Loads

Transverse and longitudinal load due to conductor tension

- Changes in line direction
- Span length variation
- Unbalanced ice
- Broken wires
- Dynamic loads
Foundation Design Process

- Single Pole w/o Guys (self-supporting)
  - Large overturning moment (M)
  - Relatively small horizontal load (H)
  - Vertical load (V) driven by structure/foundation weight and wire
  - Typically use drilled piers, driven steel caissons
Foundation Design Process

Lattice tower w/o guys

- Small base moment
- Relatively small shear load
- Large vertical load, downward or upward
- Typically use caissons, spread footings, or driven piles
Subsurface Conditions

- Borings taken at each pole location:
  - Identify cobbles, boulders or other obstructions
  - Drivability a concern
- Soil profile:
  - Low blow counts
  - Soft organic swamp deposits (organic clay, organic silt, peat)
  - Loose alluvial deposits (loose silty sand, silt)
  - Glacial till (stiff sandy lean clay, stiff clayey sand)
River Crossing Challenges

- Potential challenges include:
  - Dynamic terrain changes
  - Unique structure loading
  - Poor soil conditions
  - Unfavorable construction access
  - Environmental restrictions

- Must use communication and collaboration to overcome challenges
  - Engineers, owners, and contractors must work together
Design Alternatives
Alternatives

Considerations:

Traditional Drilled Piers
- Deep, permanent casing, spoils, many concrete trucks (access)

Driven Piles with Pile Cap
- Concrete, pad excavation with high water table

Vibratory Caissons
- Eliminate need for large amounts of concrete
- Minimal equipment needed
- Requires soils conducive to vibratory installation

Considerations:
- Cost
- Material availability
- Procurement schedule
- Hauling requirements
- Required construction equipment
- Access requirements
- Maintenance requirements
Drilled Pier with Casing
Drilled Pier with Casing
Driven Pile with Pile Cap
Micropiles
Vibratory Caisson
Design Considerations
Typical Long Span Concepts

• Tension vs. Height
  • $\uparrow$ Tension → $\uparrow$ Load and $\uparrow$ Galloping
  • $\downarrow$ Tension → $\uparrow$ Sag → $\uparrow$ Height

• Tangent vs. Deadend
  • Typically trade height for load and type
Operational Considerations

- Terrain → access for construction and maintenance
- Additional Support → lighting, supplemental power
- Ground → geotech, grounding, ground water, flood plains
- Flowing Water → flood plains, debris damage, erosion
Flood Plain Factors

- Height of foundation vs. flood plain levels
- Loading from flowing water and ice
- Loading from floating debris
- Soil erosion from water flow
- Soil bearing and skin friction assumptions
100-Year Flood Levels
Riverbank Erosion Example
Riverbank Erosion Example
Riverbank Erosion Example
Constructability
Site Conditions

**Space Availability** → Can we build there?

**Site Access** → Can we get there?

**Weather** → When can we gain access and for how long?

**Environmental** → Are there any environmental limitations to accessibility?

**Maintenance** → When do we need to get there in the future? How will we get there (once contractor is long gone)?
Installation Factors

- Site access for materials and equipment
- Limitations to construction sequence for installation
- Locations to set-up construction equipment
- Environmental factors that would limit construction
- Scheduling and coordination concerns
Construction Methods

- Experience and expertise of contractors
- Detailed review of methods (and alternatives) and expectations
- Site access requirement reviews
- Review of equipment to be used during installation
- Observation with design support during installation
Keys to Success

Create **sub-project to enhance focus**

Define **project constraints**
Scope/budget/schedule

Conduct **thorough data collection**
Know what you are dealing with  Study various alternatives  Identify all possible obstacles

Collaborate **with all parties**
Thoughtful planning  Dynamic communication  Efficient execution
River Bank Foundation Design

QUESTIONS?

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