Executive Summary, Research Readiness Level Assessment, and Technology Transfer

High Mast Tower Foundation

Research Objectives

1. Evaluated the various types of foundations used in other structures that are similar in height and shape to the High-Mast Towers. This included evaluating drilled shafts and direct embedment foundations for Power Transmission Line Structures.
2. Evaluated the corrosive environment with steel pole structure being embedded either in soil or concrete and propose mitigation measures for any corrosion issues found.
3. Based on these findings, provided design and construction provisions that will be integrated into NDOT specifications for design and construction .

Research Benefits

1. Provided an alternative base design that will eliminate the pole-to-baseplate connection that contains weldment details and bolts that are fatigue prone.
2. Reduced inspection and maintenance costs reviewing welds and bolt tightness.
3. Provided a different approach to the pole-to-ground connection that could be used nationwide

Principal Investigator

Chungwook Sim (P.I.)
Chung Song (Co P.I.)
Brandon Kreiling (Co P.I.)
Jay Puckett (Co P.I.)
University of Nebraska

Lead TAC Members

Mick Syslo,
Materials & Research Engineer
Mark Burham,
Material & Research Manager

Background

High Mast Tower (HMT) foundations have been traditionally designed and constructed using a cast-in-place foundation with anchor bolts that are used to secure the tower to the ground. This type of design requires a large base plate that is welded to the tower shaft. The Nebraska DOT (NDOT) has experienced issues with stresses that this type of design presents at the anchor bolt/foundation interface and base plate/tower shaft interface. This issue in worst case may lead to a premature failure of one of the towers at Milford, Nebraska that recently fell down during a winter snowstorm event. There have been many research efforts in the past decade to evaluate the fatigue behavior of these High-Mast Lighting Towers, to propose retrofits that could reduce wind-induced vibrations in these structure, to develop reliability-based design procedures for High-Mast Lighting structures, and field instrumentation and testing of these structures to list a few. However, while most of these studies focused on the 100-120 ft tall structure, there are limited, or no research conducted for the substructure related specifically to poles. Therefore, this study will propose studying possibilities evaluating alternative designs for the foundations, either directly buried, or through drilled shafts, that may drastically reduce the stresses that are present in High Mast Tower designs.

Conclusion

This research project objective was to develop an alternative design for HMT foundations with direct embedment of HMT which can eliminate fatigue-prone details associated with the pole-to-base plate connection which is the primary location of failure. First, the literature that includes research from academia and industry, current and proposed state of practice from industry, examples of design specifications and guidelines, and corrosion for buried structures were reviewed. Secondly, structural loads for the typical 120- and 140-ft HMTs constructed in Nebraska and the soil resistance for them were calculated. The structural loads were computed using the AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, with a spreadsheet based on the fundamental principles of structural analysis. The geotechnical foundation resistance calculations were made to check the vertical and horizontal soil capacity for the typical HMTs used in Nebraska. In addition, further parametric study was conducted using two numerical software: LPILE and COMSOL for varying soil conditions and foundation systems with different embedment length and backfill diameter for the service level base moment and shear. Required embedment length and backfill diameter are provided as a matrix using the LPILE analysis results. Finally, based on the site considerations and constructability, a draft design and construction specification for soil parameters that can be used for Nebraska soil conditions are provided.

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Interested in finding out more?
Final report is available at:
NDOT Research Website

NDOT Recommendations Based Off of Research Project

This research provided the Department an alternative design for the High Mast Tower Foundations which can eliminate fatigue-prone details associated with the pole-to-base plate connection where primary failure occurs. The Department will consider raising a tower in an operational environment to address the following:

- Ground Effect Corrosion - due to the fact that some districts have corrosive soil, and because the foundations for these HMT will not be very deep and close to the surface where oxygen content may be higher, anti-corrosion protection measures may be needed.
- A HMT designed to 80 ft, since that is the maximum height NDOT is currently considering for future applications. NDOT may consider designs up to 140 ft, if the future presents more of a need for that application
- .Check and monitor the computed the loads provided by the study for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.
- Monitoring the welding around handholds since it is a stress point.

The Department recommends a Phase II proposal and start planning for 2021 September's request for proposals.

- *As provided by Mick Syslo and Mark Burham, Lead TAC Members*

Research Readiness Level (RRL) Assessment

RRL 3

Level 3: Development – Field Level

Research/Technology developed in an operational environment (real-world situation).

This brief summarizes Project SPR-P1 (20) M111
"High-Mast Tower Foundation"
Nebraska Department of Transportation Research Program