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IEEE Guide for Transmission Structure Foundation Design and Testing

IEEE Power Engineering Society

Sponsored by the
Transmission and Distribution Committee

and the

American Society of Civil Engineers

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Transmission Structure Foundation Design Standard Committee

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Abstract: The design of foundations for conventional transmission line structures, which include lattice towers, single or multiple shaft poles, H-frame structures, and anchors for guyed structures is presented in this guide.
Keywords: anchor, foundation, guyed structure, H-frame structure, lattice tower, multiple shaft pole, single shaft pole, transmission line structure

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Introduction

(This introduction is not part of IEEE Std 691-2001, IEEE Guide for Transmission Structure Foundation Design and Testing.)

This design guide is intended for the use of the practicing professional engineer engaged in the design of foundations for electrical transmission line structures. This guide is not to be used as a substitute for professional engineering competency, nor is it to be considered as a rigid set of rules. Of all building materials, soil is the least uniform and most unpredictable; therefore, the methods described in this guide may not be the only methods of design and analysis, nor may they be appropriate in all situations. Design and analysis must be based upon sound engineering principles and relevant experience.

This design guide is the result of a major effort to consolidate the results of published reports and data, ongoing research, and experience into a single document. It is also an outgrowth of the previously published efforts of a joint committee of the American Society of Civil Engineers and the Institute of Electrical and Electronic Engineers, which combined the knowledge, expertise, and experience of both organizations in the field of transmission line structure foundation design. Electrical transmission line structures are unique when compared with other structures, primarily in that no human occupancy is involved and the loading requirements are different from other structure types. The primary loading of most conventional structures or buildings is a dead load or sustained live load and lateral wind forces or seismic loads. The primary loading of a transmission line structure is caused by meteorological loads, such as wind and ice, or combinations thereof [B68].[1] Under normal weather or operating conditions, the loads may be only a fraction of the ultimate capacity of tangent structures, but the application of the design load is short term and sometimes violent as nature unleashes its fury. In addition, a finite probability exists that the design load could be exceeded.

Foundations for transmission line structures are called on to resist loading conditions consisting of various combinations. Lattice tower foundations typically experience uplift or compression and horizontal shear loads. H-frame structures experience combinations of uplift or compression and horizontal shear and moment loads. Single pole structures experience horizontal shear loads and large overturning moments. Foundations for transmission structures must satisfy the same fundamental design criteria as those for any other type of structure—adequate strength and stability, tolerable deformation, and cost-effectiveness. In addition, transmission line structures may be constructed hundreds or thousands of times in a multitude of subsurface conditions encountered along the same route. Therefore, optimization and standardization for cost-effectiveness is highly desirable.

This design guide addresses fundamental performance criteria and the design methods associated with transmission line structure modes of loading, much of which is not found in geotechnical engineering textbooks.

Many alternative approaches can be used for the geotechnical design of foundations for transmission line structures. It is the intent of this design guide to provide several approaches to the design of various foundation types that are consistent with the present state of geotechnical engineering practice. Where several methods are presented for the design of a particular type of foundation, the design engineer should exercise sound engineering judgment in determining which method is most representative of the situation.

[1]The numbers in brackets correspond to those of the bibliography in Annex A.

Participants

At the time this guide was completed, the Foundation Design Standard Task Group of the Line Design Methods Working Group; Towers, Poles, and Conductors Subcommittee; and Transmission and Distribution Committee had the following membership:

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At the time this guide was completed, the Transmission Structure Foundation Design Standards Committee of the ASCE had the following membership:

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IEEE Guide for Transmission Structure Foundation Design and Testing

1. Overview

1.1 Scope

The material presented in this design guide pertains to the design of foundations for conventional transmission line structures, which include lattice towers, single or multiple shaft poles, H-frame structures, and anchors for guyed structures. It discusses the mode of loads that those structures impose on their foundations and applicable foundation performance criteria. The design guide addresses subsurface investigations and the design of foundations, such as spread foundations (footings), drilled shafts, direct embedded poles, driven piles, and anchors. The full-scale load testing of the above-listed foundation types is also presented.

This design guide does not include the structural design of the foundations nor the design of the structure. Citations [B5][1] and [B50] provide guidance for the design of lattice towers and tubular steel poles, respectively. The foundation engineer should have an understanding of the magnitudes and time-history of various loading conditions imposed on the foundations in order to provide a suitable foundation to support the transmission line structures under the actual loading conditions that may be reasonably expected in actual service.

1.2 System design considerations

A transmission line is a system of interconnected elements, each individually designed. The overall line must integrate all of these individual design elements into a coordinated structural system.

Every decision made for the system should consider total installed cost, of which foundations are a major consideration. For example, wire tensions are sometimes increased to minimize the number and/or height of the supporting structures. However, if a significant number of angles is in the line, total installed costs may be higher because of increased angle structure and foundation costs. Similarly, when developing structure configurations, a wider base structure could be considered to reduce foundation loads and thereby decrease the foundation cost. This must be evaluated against the added cost of widening the structure.

[1]The numbers in brackets correspond to those of the bibliography in Annex A.