

Transmission Line Design (Volume V) - Pole Structures

An Online Continuing Education Course for Engineers

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Credit: 5 Hours / 5 PDH / 5 CPD

Transmission Line Design (Volume V) – Pole Structures

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Introduction

The primary purpose of this series of courses is to furnish engineering information for use in designing transmission lines. Good line design should result in high continuity of service, long life of physical equipment, low maintenance costs, and safe operation. These courses present a generalized “how to” guide for the design of a high voltage transmission line.

The engineering information in this course is for use in design of transmission lines for voltages 230 kV and below. Designs should be adapted to various conditions and local requirements. Engineers should investigate local weather information, soil conditions, operation of existing lines, local regulations, and environmental requirements and evaluate known pertinent factors in arriving at design recommendations.

This course is based on the requirements of the National Electrical Safety Code® (NESC®). However, since the NESC is a safety code and not a design guide, additional information and design criteria are provided in this course as guidance to the engineer. The additional design criteria are based on practices of many utilities in the United States.

This series includes five volumes. For the best understanding of the material, they should be studied in order. The volumes are generally divided into the following categories.

Volume I. This volume is an introduction to transmission line design and addresses siting issues, plan and profile drawings, loading, and distribution underbuild.

Volume II. This volume is all about clearances. Ground clearances, horizontal clearances, clearances from other live parts, and clearances to supporting structures are addressed.

Volume III. This volume discusses the materials involved in transmission line design and construction including insulators, conductors and hardware.

Volume IV. This volume in the series is concerned with the structural aspects of transmission line design and includes foundations and guyed structures.

Volume V. The final volume in the series is concerned with the structural aspects of transmission line design and includes single-pole structures and H-frame structures.

Chapter 1

Single Pole Structures

During preliminary planning stages of lines above 161 kV, studies should be made to evaluate the economics of different types of structures as related to conductor size. In most instances, for lines of 230 kV and below, wood structures have historically been the economical choice.

However, in more heavily loaded situations (larger wires, longer spans) steel and prestressed concrete structures may be more economical than wood, especially considering the long-term maintenance costs associated with wood structures. In some instances, other types of material have been used because of environmental or meteorological constraints. For voltages 345 kV and above, it may be difficult to obtain long span construction utilizing wood, due to height or strength reasons.

In most instances, for lines 230 kV and below, an economic study can help to determine structure configuration, base pole class (wood, steel or prestressed concrete) and height.

Factors which limit structure spans include:

- **Strength**: Horizontal spans are limited by cross brace, poles, etc. Vertical spans are limited by crossarms, post insulators, and structure strength. For H-frame structures, horizontal and vertical spans are also limited by pullout resistance for H-frame structures.
- **Conductor Separation**: Conductor separation is intended to provide adequate space for line crew personnel on poles, prevention of contact and flashover between conductors.
- **Clearances-to-Ground**: Limits on spans are directly related to height of structures.
- **Insulator Swing**: The ratio of horizontal to vertical span will be limited by insulator swing and clearance to structure.

Historically, preliminary cost estimates have been usually based on level ground spans. With the advent of computer-automated line design and optimization software, preliminary cost estimates can now be performed using a preliminary profile digitized from the United States Geological Survey (USGS) topographic maps or from other sources. An economic study should

consider material costs, cost of foundations and erection, different structure heights, hardware costs, and right-of-way costs. The estimates are intended to give borrowers an idea as to relative rankings of various structure types and configurations such as steel lattice, steel pole, prestressed concrete pole, and wood H-frame or single pole. However, in the decision-making process, the utility may want to consider as part of the evaluation such intangibles as importance of the line to the power system, appearance, material availability, and susceptibility to environmental attack. In some areas, State or local constraints may ignore economics and specify the type of structure to be used.

The level ground span used to develop preliminary cost estimates in the economic study is determined from clearance-to-ground and structure strength. Developing a graph, as shown in Figure 1, is one means of determining the level ground span (points A and B).

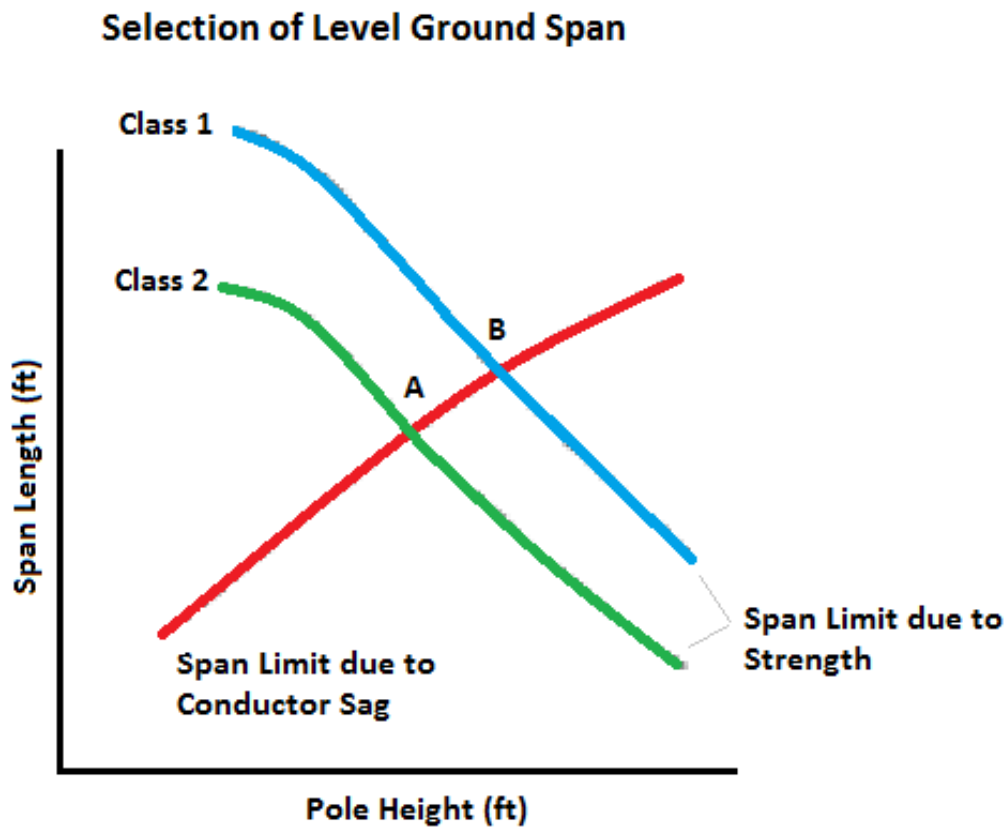


Figure 1

Cost per mile can be related to pole height and class of poles as shown in Figure 2. To keep the cost down, the line design should be based on one tangent structure type and one or two pole classes for the majority of the line. For H-frame structures, the engineer should consider double cross braced structures, as well as single cross braced structures.

Structure Cost per mile Related to Pole Height

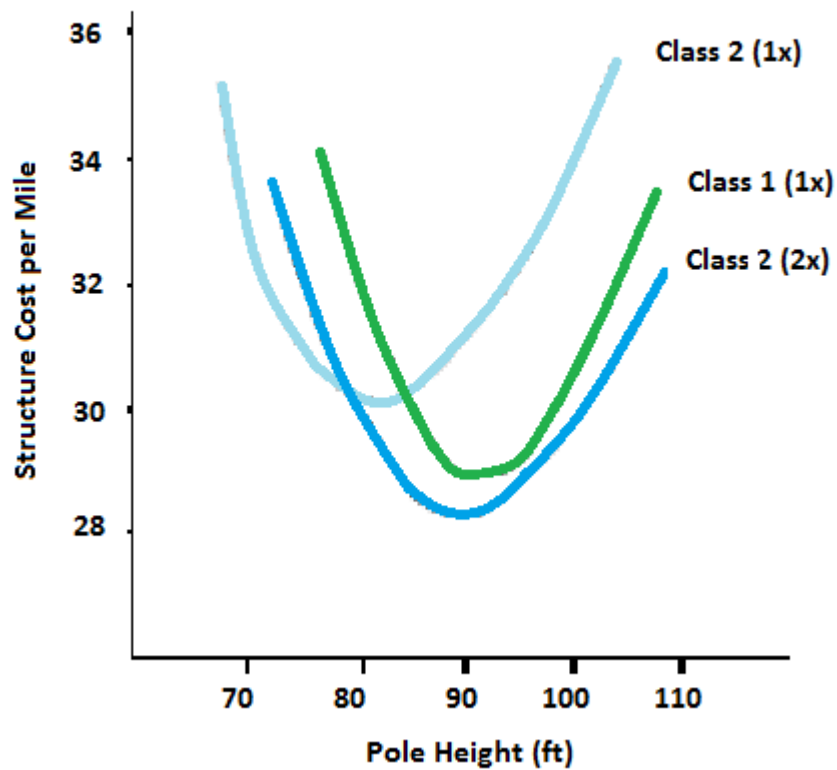


Figure 2

With the help of computer automated line design and optimization software, an economic study can be accomplished almost concurrently with the line design. If a land profile is available, or developed from USGS maps, the line designer may want to use optimization software to help determine the most economic line design. With such software, different structure types and materials and different conductor types can be evaluated. An advantage of optimization software is the use of the actual terrain (rather than level ground span) or a good approximation of the terrain. Optimization algorithms can fit structure height and type to the terrain, and can make use of different structure heights and configurations. The major

disadvantage of optimization software is that it requires input and analysis of large amounts of data.

Wood Structures - General Design Considerations

The structural stress limitations set forth in Table 1 are recommended for transmission lines using standard wood pole construction. These values assume that the wood has not deteriorated due to decay occurring in the manufacturing process.

Kind	Modulus of Rupture (M.O.R.)* (psi)	Recommended Ultimate Tensile Stress (M.O.R.)* (psi)
Western larch		400
Southern yellow pine		1000
Douglas fir		1000
Lodgepole pine		1000
Jack pine		1000
Red (Norway) spruce		1000
Ponderosa pine		6000
Western red cedar	1120	6000
Northern white cedar	800	4000

*M.O.R. = Modulus of Rupture

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Douglas fir and Southern yellow pine (SYP) are used for crossarms. Southern yellow pine has four species which are long leaf (most popular species), loblolly, shortleaf, and slash. The coast type Douglas fir is the only type which should be used when specifying Douglas fir for crossarms. Table 2 gives strength properties to be used in crossarm design.