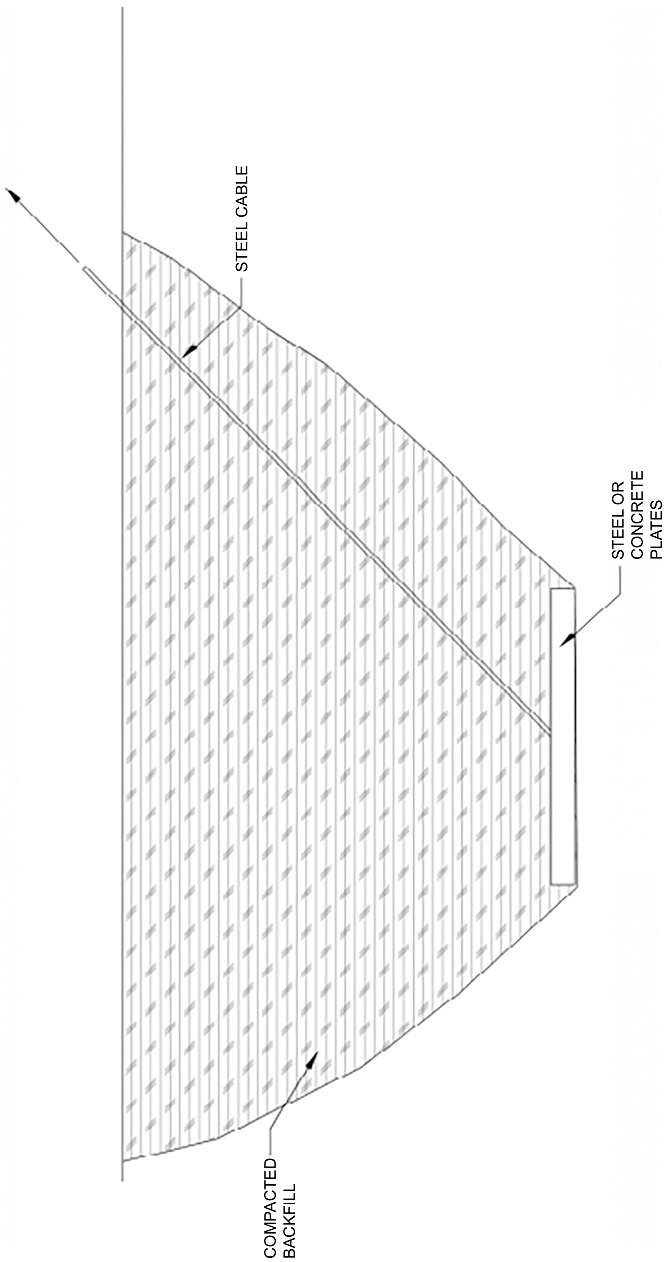

Figure 6-18. Spread anchor.
Source: Great River Energy, reprinted with permission.

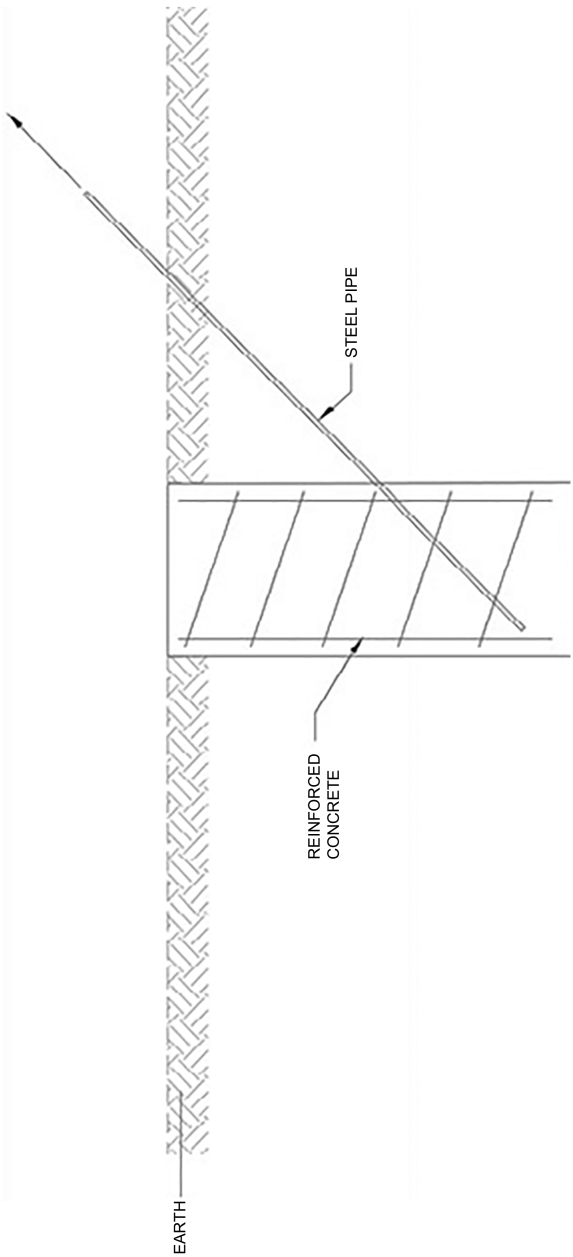

Figure 6-19. Drilled shaft anchor.
Source: Great River Energy, reprinted with permission.

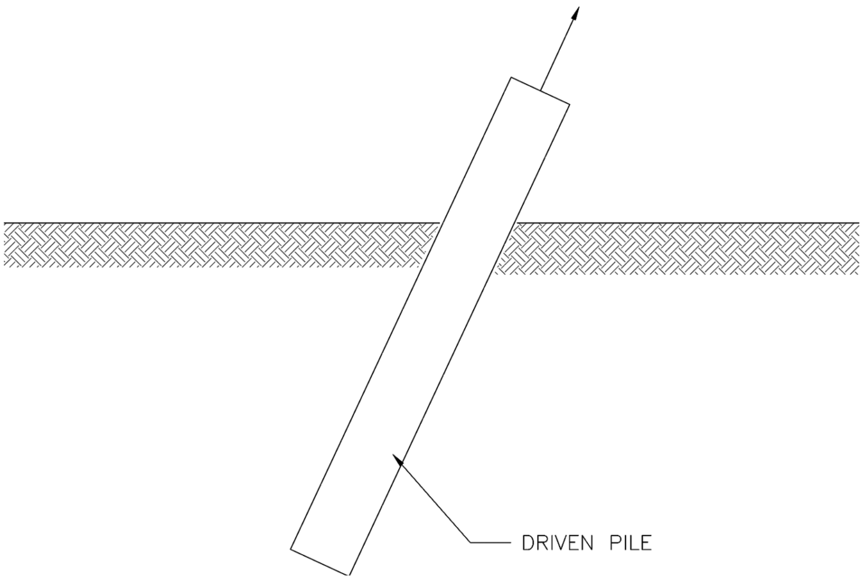

Figure 6-20. Pile anchor.
Source: Great River Energy, reprinted with permission.

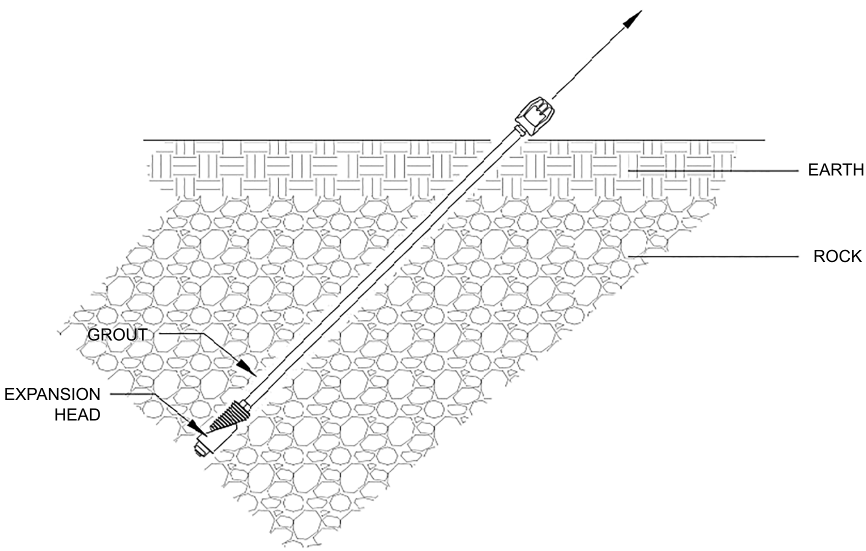

Figure 6-21. Grouted rock anchor.
Source: Great River Energy, reprinted with permission.

assumed shear plane. The load resistance is equal to the weight of the rock plus the shear strength of the rock along the assumed failure plane.

6.4.5 Anchor Installation and Testing

Anchors should be tested to ensure they can accommodate the design load. Soil conditions can vary, greatly affecting the pullout strength of any given anchor. Two common types of testing methods are pull testing and torque testing. Always follow the manufacturer's installation and testing procedures when using anchor systems.

6.5 FOUNDATION SUMMARY

Many variables need to be considered in the design of a wood structure embedment. Among these are lateral loads, vertical loads, soil strength, performance, reliability, deflection, water table, side slope, frost line, and right-of-way considerations. Because of these variables, the standard "rule of thumb" method of 10% of the pole length plus 2 ft (10% + 2) is not recommended for foundation embedment design. Foundations should be designed based on actual loading and project-specific soil conditions.

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CHAPTER 7

MANUFACTURING AND QUALITY ASSURANCE

7.1 GENERAL

A natural round wood pole is not an engineered product. The purpose of this chapter is to help the engineer understand components of the manufacturing process and quality assurance for poles to perform as intended. The manufacturing requirements specified in ANSI O5.1 (ANSI/AWPA 2017), Canadian Standards Association CAN/CSA O15 (CSA 2015), and American Wood Protection Association (AWPA) Standard U1, Commodity Specification D: Poles (AWPA 2018), and RUS Bulletin 1728H-702 (USDA 2011) should be closely monitored by the manufacturer to ensure that the quality of the poles meets or exceeds the minimum standards.

The variability of wood poles is quantified by the coefficient of variation (COV). As indicated in Chapter 4, the high COV of wood poles means a greater percentage of the population is able to withstand loads that are higher than the required ultimate strength. This helps wood poles resist extreme loading events better than materials with a low COV. Natural round wood poles, with their inherent qualities and manufactured with effective quality assurance, are a reliable structural material for design for engineers.

7.2 MANUFACTURING PROCESS

The manufacturing process starts by harvesting select timber that is transported to a manufacturing facility. After peeling the bark and additional preparation, poles are sterilized before the pressure treatment process to eliminate internal decay fungi.

Figure 7-1. Forested area where wood poles are harvested.
Source: Bell Lumber and Pole Company, reproduced with permission.

7.2.1 Harvesting Timber in Woodland

The most important step in the pole manufacturing process is the selection of the whitewood. There are many options for obtaining the whitewood. The process can take from one day to eight months, and in some cases even longer. This wide variance of time depends on the species, class, length, and quantity of poles the customer requests. In a stand of trees, approximately 5% to 7% of the selected timber will meet the quality standards of a wood utility pole. The remaining timber is used for dimension lumber, pulp, and other applications (USDA Forest Service 2010).

Trees in the forest (as shown in Figure 7-1) are selected for utility poles by a forester and are marked for the anticipated class and length. The basal area is the space that allows other trees to grow in the optimal spacing after a tree is marked for harvest. The forester follows accepted practices by selecting trees within a basal area. The circumference at 6 ft from the butt is measured to determine the expected class of the pole. The height is determined by either laser measurement or visual approximation by the forester.

The tree is then clearly marked for the harvester/logger to see and is written into a logbook, with its circumference measurement, to keep an accurate account. Figures 7-2 and 7-3 show that the soon-to-be pole is cut and de-limbed in the forest by machine. It is then put on a logging trailer and trucked to the peeler for inspection and verification of the class and length, before final manufacturing.

Figure 7-2 (left) and Figure 7-3 (right). Pole harvesting from a basal area.
Source: Bell Lumber and Pole Company, reproduced with permission.

Figure 7-4. Peeling process.
Source: Bell Lumber and Pole Company, reproduced with permission.

7.2.2 Peeling

Peeling or debarking the pole is performed by a machine-operated rotary blade and a conveyer system as shown in Figure 7-4. This operation is typically controlled by a skilled worker to maintain proper depth of the debarking process.

The bark is then reclaimed and used for landcaping mulch, animal bedding, or hog fuel for cogeneration plants. The poles are sorted and inspected per the specifications (ANSI, AWPA, CSA, or RUS) as explained in Section 7.1. At this point the poles are termed to be "in the white" as shown in Figure 7-5.

7.2.3 Preparation for Treatment

The next step in manufacturing poles is the preparation before conditioning and treatment. This is when the final class and length are established, marking/branding takes place, the groundline zone for Douglas fir and Western red cedar poles is defined and prepared, the predrilling of framing holes is performed, and final whitewood inspection is completed.

Drilling the framing holes before treatment helps to ensure effective treatment and proper hole drilling and may save time in the field for installation.

Figure 7-5. Wood poles after peeling.
Source: Bell Lumber and Pole Company, reproduced with permission.

One caveat is that the structure framing drawing details given to the manufacturer must be clear, correct, and easy to implement. Tolerances should be defined by the engineer for the manufacturer to ensure that the holes are properly located and oriented on the pole.

The predrilled holes are bored by hand, machine, or precision drilling. If the tolerances are tight, a precision-drilled hole is the best. As tolerances get larger, machine- and hand-drilled methods are adequate. It is important to note that precision drilling takes more time and affects the rate of production for the manufacturer, which in turn also adds to the overall cost.

Poles made of Douglas fir and Western red cedar need additional preparation in the groundline zone to improve the penetration of the preservative in areas where future decay is most likely. The engineer must therefore calculate the required embedment depth prior to placing the pole order and specify the length of the zone above and below the expected setting depth for additional pretreatment processes. The manufacturer will label the poles according to the results of the final manufactured product. If no instructions are given about the location of the groundline zone or the required embedment, the manufacturer will default to a groundline location of 10% of the length of the pole plus 2 ft.

Through-boring, radial boring, and incising are three processes commonly used to prepare thin sapwood species for treatment. The heartwood does not accept preservative during the treatment process, so these preparation methods enhance the penetration. Engineers must consider in their design whether these processes have any effect on strength.

Douglas-fir poles are most commonly prepared for treatment with through-boring and radial boring, although incising can be performed. Figure 7-6 shows a typical through-boring pattern, and Figure 7-7 shows a pole after through-boring is completed. Figures 7-8 and 7-9 show a typical pattern for radial boring and poles after radial boring is completed.

It is more common for Western red cedar poles to be prepared for treatment in the groundline zone with incising. This process perforates the pole with small knives or pegs to open avenues of penetration to ensure uniform and adequate preservative distribution. The depth of the incising ranges from 5/8 in. to 1 in. and typically extends 1 to 2 ft aboveground and 2 to 4 ft belowground. Figures 7-10 and 7-11 show a pole during and after incising.

7.2.4 Seasoning and Conditioning

Poles that are termed "in the white" are also considered to be in a green state, indicating a high moisture level in the pole. Air seasoning is recommended for Western red cedar so that the poles can dry from the green state. This is accomplished after the poles are inventoried and stored for