PFRC UTILITY POLE - *Wood Equivalent*

Pultruded Fiber Reinforced Composite (PFRC) poles are significantly different in properties and characteristics than the more commonly used wood utility poles, as described in the American National Standards Institute (ANSI) document *American National Standard for Wood Poles – Specifications and Dimensions*. Since utilities are familiar with the wood pole classification system, it is convenient for PFRC poles to be classified in a similar manner to facilitate their usage. PFRC poles are engineered products with consistent dimensions and properties, in comparison to naturally grown wood product with inherent variability. Due to the different characteristics between naturally grown wood and an engineered pole, the equivalency of a given PFRC pole is designed with different size characteristics and will have a different average strength to meet the same application of a wood pole. This is possible because PFRC poles have a lower coefficient of variation (COV) as compared to wood.

ANSI provides the COV values for different species of wood confirmed through historical testing. The approximate COV of wood commonly utilized is 20%. It is obvious that the wood pole has a high degree of variability with a percentage of the poles having a lower strength than their mean value. For this reason, the NESC requires strength factors be applied to the published wood strength for the purposes of designing safe wood structures.

The NESC defines grades of construction for utility poles on the basis of the required strengths for safety. Grades are categorized by application overload factors and pole material strength factors. These Grades are typically B and C. Grade B pole applications are a higher grade, more conservative installation with higher safety factors and lower potential load applied to the structure. Grade C pole applications are a lower grade, less conservative installation with a lower safety factor and higher potential load applied to the structure.

For example, refer to NESC Table 261-1A of Section 26 (Strength Requirements). For Grade B construction, the NESC specifies a material strength factor of 0.65 to be used for the applications of a wood pole. For an ANSI Class 3 pole at 3000 lbs mean strength, the corresponding Grade B design strength (pole minimum strength) is 1950 lbs (3000 lbs x 0.65). For an ANSI Class 3 pole at 3000 lbs mean strength, the corresponding Grade C design strength (pole minimum strength) is 2550 lbs (3000 lbs x 0.85). The Grade B and Grade C strength requirements are to be used in conjunction with overload factors as shown NESC Table 253-1 of Section 25 (Loading for Grade B & C). Strength factors and overload factors are used to determine the safety factor of a pole.

For products with a degree of variability, it is important to analyze their strength by statistical methods. The lower exclusion limit (LEL) of a product can characterize its minimum strength. A 5% LEL selection of a product equates to the selection having 95% of the product expected to exceed its minimum strength. To apply these statistical methods correctly, product testing must be performed to verify mean values and COV percentages.

<u>For example, consider the 5% LEL of a Class 3 wood pole at 3000 lbs mean strength</u>:

$$5\%\text{LEL (lbs)} = \text{material mean strength (lbs)} \times (1 - 1.645 \times \text{material COV \%})$$

$$5\%\text{LEL (lbs)} = 3000 \text{ (lbs)} \times (1 - 1.645 \times 0.20)$$

$$5\%\text{LEL (lbs)} = 2013 \text{ lbs}$$

[Note: the 1.645 factor is known as the K-value. The value of 1.645 is taken from practice applied by the Structural Reliability – Based Design (SRBD) guidelines for utility pole analysis.]

Comparing this 5% LEL 2013 lbs strength of a Class 3 wood pole at Grade B construction requiring the minimum design strength of 1950 lbs, it shows that greater than 95% of the wood pole population would meet the design strength requirement. Now comparing this same pole to a Grade C construction requiring the design strength of 2550 lbs, it shows that approximately 79% of the same wood pole population would meet the design strength requirement resulting in a higher LEL %. Grade C a less conservative pole application utilizing a greater amount of the wood pole strength. Grade B is a more conservative pole application.

Our PFRC poles have had extensive testing to determine their bending strengths and statistical averages. The majority of the poles tested representative of the pultrusion process and our standard production practices have a COV range of 2 – 4 %. Many poles have tested below a 3% COV. Our COV takes into consideration not only the product, but also the product from different production lots and different test equipment used to verify the mean value. Applying the 5% LEL analysis, an engineered pole with a low variability can be efficiently designed to meet either the construction of Grade C or Grade B. The mean strength of a PFRC pole can be lower than the mean strength of an equivalent wood pole for the same ANSI Class. The following examples compare different mean values and COV percentages based on recent Powertrusion testing (see Test Report No: 050703 rev0).

<u>Consider the 5% LEL of a Class 3 pole at 2725 lbs mean strength with a COV of **3.41%**</u>:

5%LEL (lbs) = material mean strength (lbs) x (1 – 1.645 x material COV %)

5%LEL (lbs) = 2725 (lbs) x (1 – 1.645 x 0.0341)

5%LEL (lbs) = 2572 lbs

<u>Consider the 5% LEL of a Class 2 pole at 3350 lbs mean strength with a COV of **2.75%**</u>:

5%LEL (lbs) = material mean strength (lbs) x (1 – 1.645 x material COV %)

5%LEL (lbs) = 3350 (lbs) x (1 – 1.645 x 0.0275)

5%LEL (lbs) = 3198 lbs

In both examples, either PFRC pole at its respective mean strength and COV would qualify as a Grade C or B wood equivalent for the given class application. In this example, the Class 4 (as reported) can be assigned as a **<u>Class 3</u>** and the Class 3 (as reported) can be assigned as a **<u>Class 2</u>**.

Consider Table 1 below describing ANSI O5.1 Wood Class strength ratings and NESC Table 261-1A strength factors applied to Grade C and Grade B wood applications. The wood strengths as governed by the ANSI and NESC are compared to the Powertrusion PFRC pole at the COV of 3.5%. Comparing Grade B and Grade C construction, Grade C requires higher design strength for any given pole class application. Applying the 5% LEL analysis, the Powertrusion *Engineered* pole and its low variability can be efficiently designed to meet the strength requirements of both the Grade C and Grade B construction.

Table 1. Powertrusion MEAN Values for ANSI Class Poles

ANSI O5.1 Class	ANSI Wood Strength Requirement at 20% COV	NESC Wood <u>Grade B Minimum Strength Requirement</u> at 0.65 Strength Factor & 20% COV	NESC Wood <u>Grade C Minimum Strength Requirement</u> at 0.85 Strength Factor & 20% COV	PT PFRC <u>Grade C Wood Equivalent</u> at 5% LEL & 3.5% COV	**<u>PT PFRC MEAN VALUE</u> for Grade C & Grade B Construction**
4	2400 lbs	1560 lbs	2040 lbs	2073 lbs	**2200 lbs**
3	3000 lbs	1950 lbs	2550 lbs	2568 lbs	**2725 lbs**
2	3700 lbs	2405 lbs	3145 lbs	3157 lbs	**3350 lbs**
1	4500 lbs	2925 lbs	3825 lbs	3864 lbs	**4100 lbs**