A "Plug" for Power Line Structures

By David C. Gelder, P.E.

Within the structural community, there seems to be a lack of awareness, as well as a growing opportunity, regarding overhead electrical transmission and distribution structures. In the United States alone there are millions of miles of corridor consisting of aging single- and double-pole structures and lattice towers. These structures form an impressive network, supporting high and extra-high voltage wires (12 kV to 765 kV) and delivering power from generation facilities to customers located hundreds of miles away. This enormous infrastructure, known as the electric grid, is a critical system to society and constitutes a specialty market for structural engineers. I wish to "put in a plug" for power line structures to increase awareness and interest among fellow structural engineers.

In 2011, when I graduated, it was still difficult to get an interview – let alone a job – with a structural firm. Given the slow job market, I pursued a master's degree. The following year, I graduated and found employment, though not designing buildings as I had supposed, but rather designing transmission structures. Interestingly, five fellow graduate students found similar entry-level positions designing either transmission structures or wind turbines – all structures within energy sector markets. In retrospect, this hiring trend may not have been coincidence, but rather a lesson in diversification: the energy market showed signs of growth during the recession, while the commercial building market all but collapsed.

I was both excited and curious about my first engineering job in this non-traditional field. After all, power lines are electrical systems, right? While they are indeed electrical systems, there is also a huge civil engineering component – as well as environmental, archeology, survey, construction, permitting, and other disciplines. It seems obvious now, but many fellow civil and structural engineers have yet to realize that we are more academically prepared than any other discipline to design transmission structures, including the poles, towers, wires, and foundations.

While considered an eyesore by many, these structures are undoubtedly critical to society. When properly designed, power lines provide an invaluable service to consumers; however, when defective or deteriorated, power lines may yield devastating consequences to the public – particularly during extreme weather and loading conditions. Transmission lines have failed in a variety of ways. In extreme cases, power lines have been blamed for igniting wildfires leading to loss of life, extensive loss of property, and environmental damage. Failure has also triggered power outages such as the infamous Northeast Blackout of 2003, which led to loss of life, water supply contamination, transportation system closures, and billions of dollars in negative economic impact. Not all failures pose equal risk, but clearly proper design of poles and towers of all voltages is critical to safeguard public health and safety.

Transmission structures are typically designed to withstand ice accumulation, as well as extreme wind and temperature loading using at least 50-year recurrence intervals. Originally most wire systems were copper; now most modern wires are aluminum, including aluminum conductor steel-reinforced (ACSR) pulled to thousands of pounds of tension. They are designed to meet ground and wire-to-wire clearance requirements at all times in accordance with the Institute of Electrical and Electronics Engineers (IEEE) *National Electrical Safety Code* (NESC) and other codes. Loading is of course unique from buildings. For example, loads on a single-pole foundation may consist of relatively light axial load (10-30 kips) combined with heavy shear (50-100 kips) and heavy bending moment (1,000-3,000 kip-ft). Poles and towers have a relatively low seismic base shear; therefore, earthquake loads rarely govern the design. Some additional tools used by today's practicing transmission engineers include modern nonlinear finite element software and Light Detection And Ranging (LiDAR) data, which are widely used in all aspects of design and analysis. ASCE/SEI issues Standards 10 and 48 – for designing steel towers and poles, respectively – and hosts the triennial Electrical Transmission & Substation Conference (this year it will be held September 27 – October 1, 2015 in Branson, MO).

On the business side, historically power lines were designed, built, and maintained for the most part in-house by electric utilities. Now, much of the design knowledge base and workforce has transferred to consulting firms, so many utilities rely on them to help complete projects. Large projects are often offered as engineer-procure-construct (EPC) contracts – similar to design-build contracts – while many smaller projects are simply awarded as part of a master service agreement (MSA). Due to the increasing demand for power, the aging infrastructure, and a retiring workforce, there is a growing need for transmission engineers. This poses an opportunity for structural engineers either individually or as a firm. For example, some structural engineers have chosen to pursue transmission engineering as a means of specialization. Additionally, some large civil engineering firms have chosen to offer power delivery services in order to diversify, though newcomers have found the market extremely difficult to penetrate.

In summary, power line design can be an enjoyable and rewarding career path for structural engineers, and the power delivery market can be a means of diversification for their firms. The greater civil and structural engineering communities will benefit by recognizing and promoting these poles and towers as *civil* structures. Lastly, power line structures may be viewed by some as an eyesore, but for others, they represent an opportunity.▪

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