3. Identify hydrodynamic and wind loads.
4. Determine the design tension of the wire rope at the midpoint and the cable saddles by analyzing the distribution of the total design load via the suspension system and the sag-span ratio of the wire rope.
5. Utilize design procedures as specified in the "Design Manual for High Voltage Transmission Lines" Rural Electrification Administration (REA) Bulletin 62-1, Department of Agriculture. The Class I SYP transmission poles were checked to determine the maximum safe vertical load against buckling. While using this reference may seem odd at first, one will quickly recognize that transmission lines are "suspension structures." The REA manual presents the practical experience accrued from millions of miles of transmission lines. The REA procedure indicated that the poles discounting the structural benefits of intermediate cross-members could support 42,600 pounds with a safety factor of 3. This is 1.9 times the design load of 22,000 pounds.
6. Utilize design procedures for tapered poles as specified in Section 5 of the "Timber Construction Manual" 3rd edition, AITC. This is a more detailed design procedure than the REA methods. This incorporated the following elements:
   - Adjustments for taper
   - Identification of slenderness ratio and column classification
   - Euler formula for ultimate buckling strength
   - Live load duration modification factor
   - Allowable bending stress of 1,700 PSI (pounds per square inch)
   - Allowable compression parallel to the grain of 900 PSI
   - Modulus of elasticity of 1.5 million PSI

The AITC design procedure identified the allowable axial load on the poles as 32,500 pounds, or 1.48 times the design load of 22,000 pounds.

This six-step procedure resulted in the pole towers detailed on Plan Sheet 4 and Figure 3 on the following page.

Tower Installation

The photographs on pages 20 and 21 provide a pictorial of the tower installation. The extremely poor subsurface conditions required an extensive foundation system. The connection between the towers and the foundation required the poles to be in their final upright position prior to the foundation construction. This required the tower poles to be installed first on a temporary basis with braces and guylines. The foundation, which will be reviewed at length on pages 23-39, was installed immediately afterwards.

As indicated in the photographs, the first step was to auger holes for the poles. The poles were embedded in the soil a minimum of 6 feet for structural and safety purposes. This is common practice for 40-foot poles. Although the ground elevation varied from pole location to pole location by as much as 15 inches, it was important that all four pole tops be at the same elevation. Elevation benchmarks and a surveyors level were used to identify the embedment depth for each pole to ensure a common top elevation to the extent practical. The poles were winched up as shown in photos 2 and 3. Note that the top guyline cable bands were installed before the poles went up. The Chance® Power Installed Screw Anchors (PISA®) for the guylines were also installed before the poles went up. The pole bases were backfilled and tamped. As shown in photos 4 to 9,

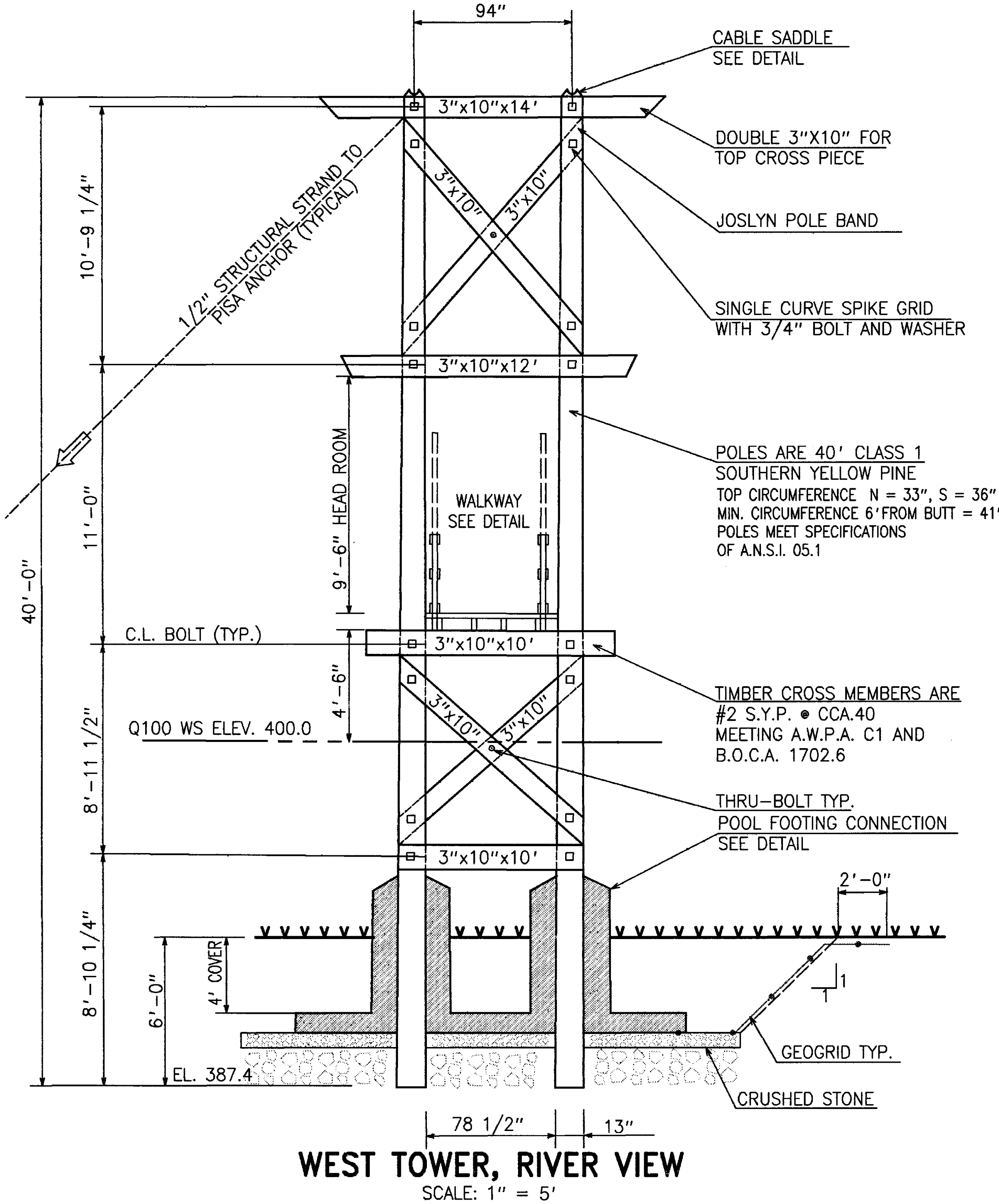

Figure 3. West Tower, River View. *Design plans courtesy of Tibor Latincsics, Conklin Associates.*

Photo 2. Installation of the west poles. The east tower is in the background. *Photo courtesy of Mr. Stephen Klein, Jr.*

Photo 3. Installation of the west poles. *Photo courtesy of Mr. Stephen Klein, Jr.*

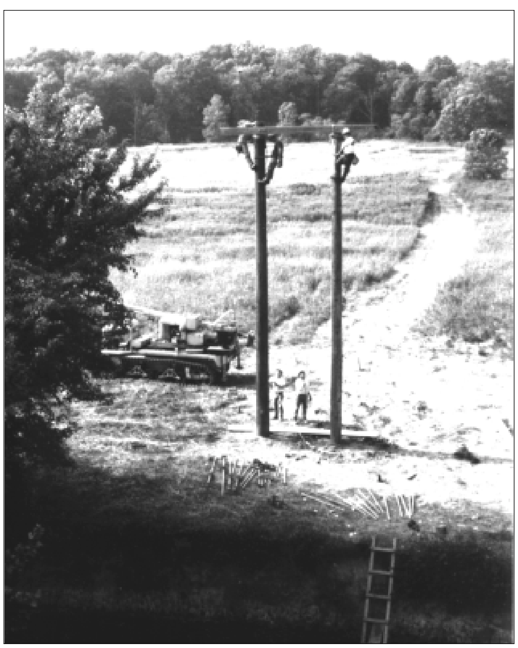

Photo 4. GPU Energy volunteers installing the tower cross-bracing on the west tower. *Photo Courtesy of Mr. Paul DeCoste.*

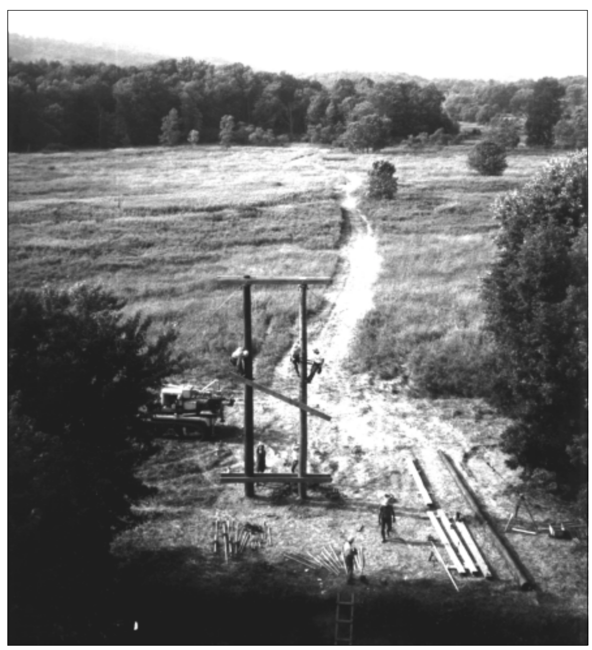

Photo 5. GPU Energy volunteers installing the tower cross-bracing. *Photo Courtesy of Mr. Paul DeCoste.*

Photo 6. GPU Energy volunteers installing the cross-braces and guylines. *Photo Courtesy of Mr. Tibor Latincsics.*

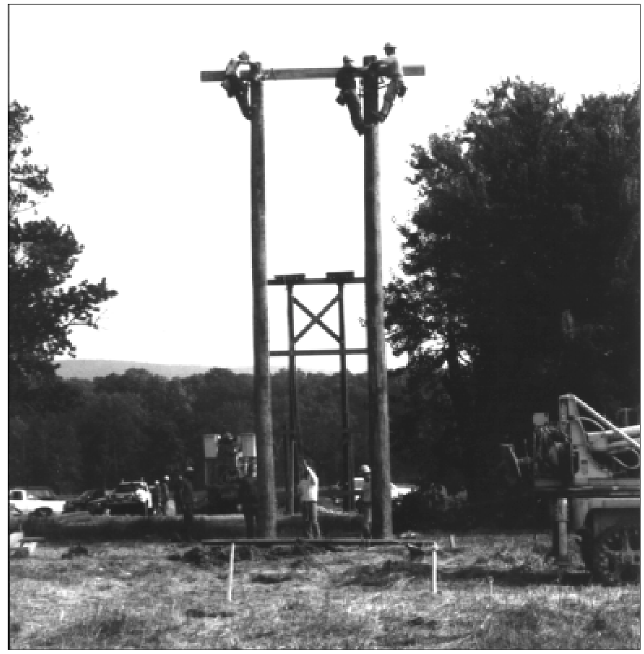

Photo 7. GPU Energy volunteers installing the cross-braces and guylines. *Photo Courtesy of Mr. Tibor Latincsics.*

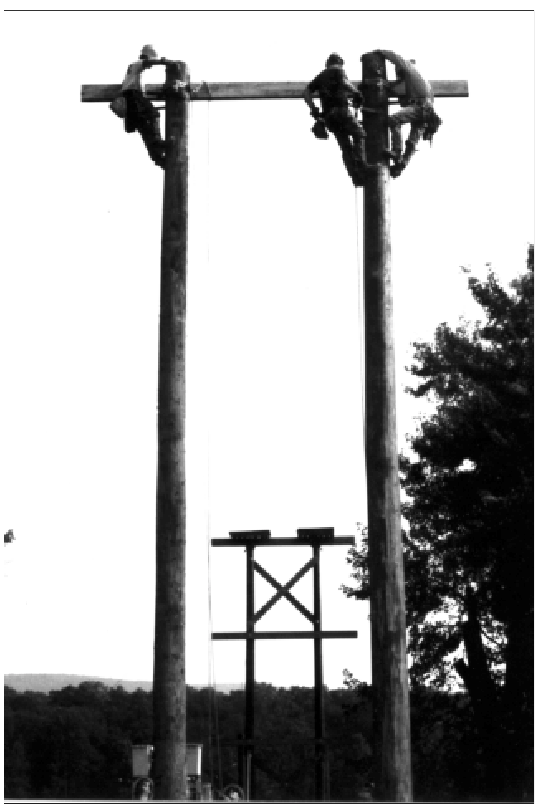

Photo 8. GPU Energy volunteers installing the cross-braces and guylines. *Photo Courtesy of Mr. Tibor Latincsics.*

Photo 9. GPU Energy volunteers installing the cross-braces and guylines. *Photo Courtesy of Mr. Tibor Latincsics.*

GPU Energy volunteers climbed the poles and set the top cross-braces and guylines. The 1/2-inch structural strand guylines with preform ends shown in photo 9 were attached. These were also used to "plumb up" the poles. With the poles plumb, the remainder of the cross-braces and diagonals were installed. Galvanized 3/4-inch bolts and single curve spike grids were used to make the connection between the transmission poles and the 3-inch by 10-inch cross-braces. Spike grids (also known as gain grids) are most often used in heavy timber and pole construction, such as with docks and bulkheads. A well-known manufacturer of spike grids is Cleveland Steel Specialty (14400 South Industrial Avenue, Cleveland, OH 44137; Phone: 800-251-8351). The galvanized, malleable iron grids come in three configurations: flat, circular, or single curve. All three are sized for either a 3/4-inch or a 1-inch bolt.

The advantage of using the spike grids is that in lieu of the cross-arm or diagonal load being transferred to the bolt alone, the load is also transferred to a larger wood area. The spikes of the grid press into the wood fiber of both members and improve the shear and rotation resistance of the bolted joint. The single curve spike grids are specifically made to increase the bearing surface between a round pole and flat lumber. Spike grids have the added benefit of providing ventilation, which eliminates the potential decay at the contact area between the two wood surfaces. Spike grids increase the strength of a bolted timber connection. The 3-inch by 10-inch cross-braces were installed with the "bark side" towards the pole, so if the lumber cups, it improves the spike grid embedment.

As shown in photo 10, the two towers were also guyed to one another with structural strand guy wire. The Pochuck Quagmire Bridge is the only pedestrian bridge among those inventoried that utilizes guylines to brace the top of the towers. For the long term, the guylines can be viewed as "cheap insurance" as well as a cost-effective way of reducing the Euler effective length of the towers. The fact that GPU Energy donated all the guyline hardware and performed all the installation made it easy for the project partners. The guylines were essential to the sequence of construction. The foundation excavation could not have been performed without the guylines securing the cross-braced poles. Under normal loading conditions the guylines do not play a structural load. The guylines do have a structural benefit under extreme wind loads.

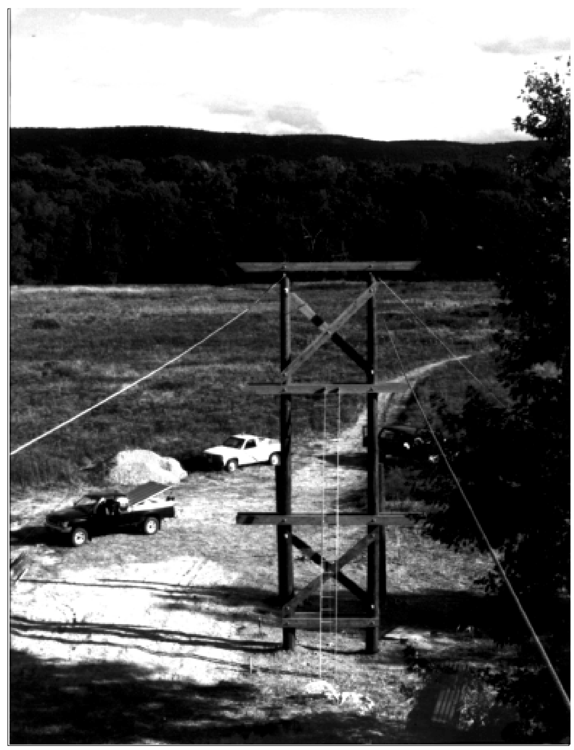

Photo 10. View from the east tower looking at the west tower and Wawayanda Mountain during construction. Shows the structural strand guylines running between the towers. *Photo Courtesy of Mr. Tibor Latincsics.*

As will be reviewed in greater detail later, the guylines running between the tower tops, as shown in photo 10, served an important role in the assembly of the walkway. It is important to remember that a portion of the horizontal load that guylines counteract is transferred to the towers as an axial load. Guylines can be very beneficial, but the designer must incorporate the loads in the tower and foundation design. The end result, as shown in photo 16 (page 29), was that the towers were framed out, guyed in all four directions, and embedded 6 feet in the earth. It was then practical and safe to excavate around the tower bases to construct the foundation.