Spelter Sockets

Photo 55 shows the termination of the wire rope in open spelter sockets. These in turn connect to a 1 3/4-inch by 24-inch turnbuckle with one closed and one open end, which in turn connects to the end of the Chance® 1 3/4-inch square shaft helical simplex anchor, with a chain shackle. The turnbuckles are rated for 28,000 pounds working load and 140,000 pounds ultimate load. The entire assembly is detailed on page 40 (Figure 7) and Plan Sheet 7.

There are only two ways to attach anything to the end of a wire rope. Either form a loop in the wire rope or attach a fitting to it. Following is a listing of various types of attachments and the approximate efficiency of the attachment as compared to the strength of the rope. See Figure 13 (page 56) for various types of attachments.

- Bridge socket (closed or open) = 100 percent
- Molten zinc or resin spelter sockets (PQB main cables) = 100 percent
- Cold formed swaged sockets (PQB suspender) = 95-100 percent
- Mechanical splice loop (PQB flemish sleeve) = 90-95 percent
- Hand tucked splice loop = 80-90 percent
- Wire rope clips = 75 percent
- Wedge sockets = 75 percent

The working load capacity and safety factor of a wire rope system is based on its weakest link. The selection of the proper (or practical) attachment method for a wire rope can have major impacts. Doran Sling in Hillside, New Jersey, prepared resin spelter sockets for use on the Pochuck Quagmire Bridge. They resulted in 100 percent efficiency of the 105,619 pounds of the breaking strength of the wire rope. They are also a relatively vandal proof attachment. What the spelter sockets do not provide is field adaptability. The calculated length of the cut wire rope had better be correct.

In the case of the Pochuck Quagmire Bridge, once the towers and cable saddles were installed, the as-built dimensions of the bridge were measured every which way. The saddle-to-saddle span and elevation difference was measured. The saddle apex to square shaft rod top for each backstay was measured. Each measurement was made by an electronic distance meter and double checked with a calibrated steel tape. The take-off elevation of the as-built towers, the 3.5 percent grade of the walkway, and the K suspender length established the final sag elevation of the catenary cable sag low point. As shown on Plan Sheet 1, each pair of suspenders had an alphabetical designation, A through K. The K suspender is at the midpoint of the span and the lowpoint of the catenary cable. The length of the various attachments were incorporated. All this as-built information and the equation on page 50 identified the 202.00 and 200.94 lengths of the south and north cables. Various volunteers asked why all the fuss about the cable length when there is 24 inches of adjustment because of the turnbuckles at either end of each cable. The position of the project engineer was that the turnbuckles
Figure 13. Attachment options for end of a wire rope. *Courtesy of the Wire Rope Technical Board.*
were to micro-tune the bridge and for long-term stretch in the wire rope. One should not squander this capability by not accurately calculating the cable length.

The author’s field inventory of 31 trail suspension bridges showed that wire rope clips are the most frequently used terminal attachment method in the eastern states. The exceptions to this are the Pochuck Quagmire Bridge and the White Mountain National Forest bridges, which used spelter sockets. Bridge sockets are utilized on USDA Forest Service bridges in Idaho and Montana. While wire rope clips are less efficient than a bridge socket, spelter socket, or a swaged connection, they are easy to install in the field. They also provide for an easy method of adjusting the catenary cable length during initial installation. In using wire rope clips, one must recognize the 25 percent reduction in the wire rope assembly strength. The wire rope clips are the weak link. Structural efficiency is sacrificed for practicality. Photo 57 shows a typical wire rope clip and thimble attachment.

If wire rope clips are the chosen end attachment, several basic rules must be observed. They are as follows:

- The clips must be forged steel. Malleable clips are only appropriate for light duty uses.
- A metal thimble must be used to form the loop. The bending radius and groove of the thimble must match the diameter and type of wire rope construction.
- The turnback on the wire rope must be of a specific minimum length, for example at least 26 inches for a 1-inch wire rope.
- The correct number of clips must be used. For example, five is the minimum number for 1-inch wire rope.
  - The U-bolt is applied over the dead end of the wire rope, and the live end rests in the saddle of the clip. Never saddle a dead horse! (Figure 15)
  - The clips must be uniformly torqued to a recommended torque of the manufacturer.
The field inventory did reveal a potentially dangerous situation involving the use of wire rope clips and thimbles as a terminal end attachment. As discussed in the cable saddle section, a wire rope must have a proper bending radius. Proper diameter wire rope thimbles should be used with wire rope that is manufactured for flexibility. This usually means a larger number of wire in a strand, such as a 6 x 49 construction. Structural bridge rope that is 7 x 7 or 6 x 7 should not be used with thimbles and wire rope without recognition that this combination results in a 50 percent reduction in the bridge rope strength. Structural bridge rope has a large bending radius requirement. It is manufactured to be used with spelter or swaged sockets.

### Suspender Design and Installation

The primary purpose of the suspenders is to transfer the walkway load to the catenary cables. The stiffening trusses distribute a point live load to several suspenders. This reduces the vertical oscillations of the walkway under non-uniform loading. The suspender design and installation had to meet several criteria; they had to be:

- Structurally sound.
- Vandal resistant.
- Minimum number of parts or connections.
- Have a vertical adjustment capacity.
- Practical to install under adverse conditions.
- Cost-effective with no adverse impact on public safety.

The first five would be easy to accomplish if it was not for the sixth criteria. The final suspender design is detailed on Plan Sheet 8 and Figure 16.

The suspender assembly utilized for the Pochuck Quagmire Bridge is more sophisticated, but at the same time simpler than suspender assemblies for similar bridges. Working top to bottom, as detailed on Plan Sheet 8, Figure 16, and photographs 59-62, the individual components are as follows:

- CM Big Orange Piggyback wedge socket clip attachment to the catenary cable.
- Flemish eye loop with a 1/2-inch extra heavy duty wire rope thimble and flemish sleeve.
- 1/2-inch 6 x 19 galvanized EIP IWRC wire rope.
- Muncy 1-inch thread stud, electro zinc galvanized, swaged to the 1/2-inch wire rope.
- 1 1/16-inch bore hole through 6-inch by 6-inch cross-stringer.
- 3-inch by 3-inch by 3/16-inch galvanized square washer.
- 1-inch bore galvanized square washer.
- Standard 1-inch square nut.
- 1-inch lock nut (not shown in construction photos).

A distinguishing feature is the vertical adjustment capability by utilizing the threaded stud.

Practical elements and concerns about vandalism became the determining factors in the suspender design rather than pure structural criteria. The number and 5-foot spacing of the suspenders was determined by the design of the cross-stringers. The design of the cross-stringers was in turn influenced by the size of the borehole