Packable Trail Bridges

John Kattell, P.E.
Transportation Structures Group Leader
Northern Region
Missoula, MT

INTRODUCTION

As the Northern Region bridge engineer, I enjoy inspecting trail bridges in wilderness areas, some as far as 30 miles from the trailhead. Region 1 has a number of large suspension trail bridges in the wilderness, but most of the native-log–stringer bridges are less than 40 feet long and are built with materials (trees) from the bridges' immediate vicinity. A native-log–stringer bridge in Region 1 has a life span of 10 to 20 years, and after several replacement cycles, stands of trees near the bridges are noticeably depleted.

In the fall of 1999, Nez Perce National Forest wilderness recreation managers and engineers met with local wilderness protection groups to discuss long-term plans for some of their wilderness trail bridges. All agreed that the 10-to-20–year replacement cycle and the impacts around the bridges were unacceptable. They also agreed that they should construct new bridges for a long-term life span (50 years or more) with low-maintenance requirements to minimize the need for frequent wilderness construction.

Building a bridge in the wilderness without native materials requires transporting materials to the site, accomplished in the past mostly by helicopter. Could they build a bridge without using a helicopter? Could they build it with exclusively packable materials? We decided to find out. Our objective was to develop a trail bridge for a long-term life built of exclusively packable materials with common construction practices and tools for spans up to 40 feet.

DESIGN CRITERIA

Experienced packers have some rule-of-thumb sizes and weights that mules can safely transport. Typically, a mule can carry a 200-pound load (100 pounds per side) with a maximum length per piece of 8 feet. For example, a mule could carry two 8-foot pieces, each weighing a maximum of 100 pounds. Under certain conditions the maximum length of a piece could be extended to 12 feet and weigh more than 100 pounds, but the load would need to be transported with mules in tandem. For our initial study, we chose to maintain a maximum 8-foot member length and weight of 100 pounds (figure 1).

Figure 1. *Packable stringer pieces.*

Most wilderness bridges in Region 1 are built by seasonal force account crews or are constructed in cooperation with special-interest groups familiar with the typical bridge configuration of longitudinal stringers with plank decks. Tools and equipment may range from shovels and wrenches to hi-lines and pulleys, employed to move heavy pieces. Because we wanted to design a bridge that would accommodate the skills and tools of these crews, we selected a packable bridge that the crews would assemble into a longitudinal stringer with a plank deck. Although we considered a truss bridge, which may be more efficient with respect to materials, we decided it would be more complicated, have higher labor costs, and in many instances, be beyond the skills of our crews.

For our design we chose timber materials that were esthetically suited to the environment. Also, our crews were familiar with timber, and treated timber has a long-term life expectancy. We considered steel and concrete to be too heavy, and the suitability of fiberglass is still unproven.

STAGGERED SPLICE STRINGER DESIGN

We designed a 6- by 15-inch longitudinal timber stringer with 8-foot glulam member pieces by doubling 3- by 15-inch pieces together, staggering the joints, splicing with steel plates, and stitch bolting the entire assembly together (figure 2). A single 40-foot staggered spliced stringer will have nine 8-foot pieces, two 4-foot pieces, nine steel splice plates, and approximately 170 bolts. By using the steel splice plates, the full section of both stringers can be developed to resist the forces caused by pedestrians, snow load, and other stresses. In a conventional design, the stringer size can be increased or varied so that only three or four stringers are used. With the packable design, the stringer size can vary only slightly due to size and weight constraints. The design depends on the number of stringers needed, according to the design load (typically snow load in Region 1). Usually the deck is 2-inch thick planking, with curbs or railing added.

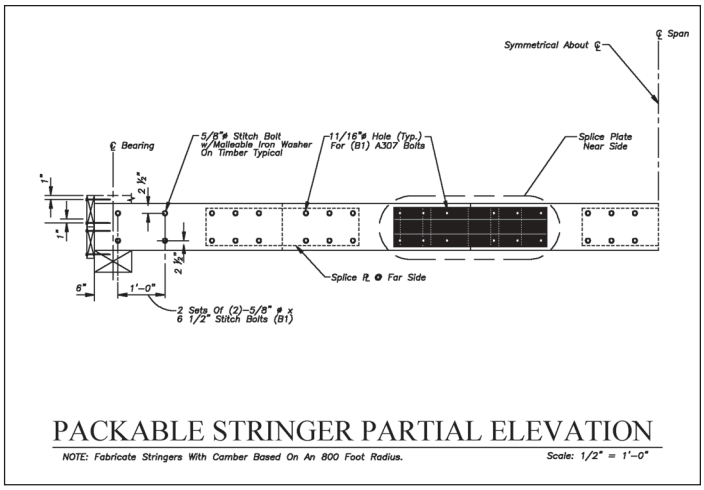

Figure 2. *Stringer detail.*

Currently, the packable-piece size restriction, combined with the splice capacity and allowable deflections, limits the maximum span to approximately 40 feet. At this length, an upward camber or deflection of approximately 3 inches can be fabricated into the stringers. Although providing upward camber is not required structurally, it is considered esthetically and functionally desirable.

CONSTRUCTION

In the past 2 years, we have designed and built five packable bridges in Region 1. All five bridges were built with force account crews on conventional spread-footing abutments with sills or short timber walls.

Dome Mountain, Kootenai National Forest (figure 3)

20-foot span, 300 pounds per square foot snow load,
seven 5- by 10.5-inch stringers
Packed 6 miles, ~ 30 mule trips
Materials cost ~ $12,000

Figure 3. *Dome Mountain.*

North Fork Rumble Creek, Flathead National Forest (figure 4)

24-foot span, 215 pounds per square foot snow load,
six 5- by 12-inch stringers
Packed 1.5 miles, ~ 35 mule trips
Materials cost ~ $12,000

Figure 4. North Fork Rumble Creek.

The following three bridges were designed and constructed under a single project and built on the Moose Creek Ranger District in the Selway Wilderness on the Nez Perce National Forest. The project won the 2002 National USDA Forest Service Chief's Award for "Traditional Skills and Minimum Necessary Leadership." (For more information on the costs and logistics of constructing these three bridges, contact JohnKattell/R1/usdafs@fsnotes).

Ditch Creek (figures 5, 6, and 7)

36-foot span, 100 pounds per square foot snow load,
four 6.25- by 15-inch stringers
Packed 1.0 mile, ~ 60 mile trips
Materials cost ~ $10,000

Figure 5. *Ditch Creek (before construction).*

Figure 6. *Ditch Creek (new trail bridge during construction).*

Figure 7. *Ditch Creek (new finished construction).*

Goat Creek

36-foot span, 100 pounds per square foot snow load,
four 6.25- by 15-inch stringers
Packed 3.5 miles, ~ 60 mule trips
Materials cost ~ $10,000

Pettibone Creek

40-foot span, 100 pounds per square foot snow load,
five 6.25- by 15-inch stringers
Packed 5.0 miles, ~ 60 mule trips
Materials cost ~ $10,000

Correct fabrication of the stringers is critical. The last thing a crew needs is to pack all the materials to the site, only to find that the pieces do not fit. The contract plans require the timber stringer fabricator to build the stringers full length with the appropriate camber, cut each member into pieces, match drill all holes, and ship the stringers fully assembled. Requiring that the stringers be shipped fully assembled, ensures that they fit, and work crews gain experience by disassembling the stringers in preparation for packing before reassembling them at the remote site.

Complete piece markings are provided on the drawings, and the fabricator is required to mark each piece accordingly. Also provided is a bill of materials for the total bridge with estimated weights.

WHAT IS NEXT?

In proceeding with this packable design, we have been cautious about adding design refinements before we could monitor the final product's performance in place and talk to the packers and construction crews. So far, all comments from the packers and construction crews have been positive. This winter we also load tested our staggered, spliced stringers (figure 8) and compared the results with full-length stringers. The favorable results encouraged us to incorporate some modifications into future bridge designs. With the success of the first five bridges and our load testing, we are making this packable bridge a standard trail bridge design with appropriate drawings and specifications. This design should be a viable alternative for wilderness bridges or anywhere access is limited and only light equipment can be used. In the future, we also plan to consider developing plans for longer spans by using post-tensioning bars beneath the stringers to increase strength and stiffness and to accommodate our snow and stock loading, while keeping deflections within allowable limits.

Figure 8. *Staggered stringer load test.*

Keywords: log stringers, longitudinal stringers, plank decks, spread-footing abutments, staggered-splice steel stringer design, timber, traditional construction fabrication, wilderness construction