Goodpasture Covered Bridge Rehabilitation

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Greg has more than 27 years of civil/structural design and project management experience, and since 1989 has had the distinctive experience of being the designer and/or project manager on rehabilitation and repair projects for 32 of Oregon's 50 covered bridges.

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Inspired by the graceful bridges on the Oregon Coast, Tony became an engineer after building custom furniture for 15 years. He's been engaged in structural design for 20 years, and has been lead design engineer on 18 covered bridge rehabilitation projects.

Summary

The Goodpasture Covered Bridge, crossing the McKenzie River, is a 72.5 m (238-foot) five-span timber structure that provides lifeline access to a large community. The main span is a 50.3 m (165-foot) covered heavy timber Howe truss. The truss chords have three leaves, each made of segments spliced together. Eight of the sixteen bottom chord splices were broken, and the truss sagged 100 mm at mid-span. Site constraints dictated that all repair work be performed under traffic and without temporary support beneath the bridge. The solution was a post-tensioning system for the bottom chords to provide an alternate load path. To lift the center of the bridge to the proper camber without support from below, a pair of tube-steel trusses were constructed inside the house to bear the loads. The bridge was lifted 200 mm at mid-span to achieve 100 mm of positive camber, and held by the steel trusses while the hanger rods were tightened and post-tensioning system installed.

Keywords: Covered bridge, rehabilitation, Howe truss, post-tensioning, repair under traffic

1. Historical Background and Context

The Goodpasture Covered Bridge was constructed by Lane County at its present location under the supervision of veteran bridge builder A.C. Striker in 1938. The main span is a housed eleven-panel, three-leaf Howe truss. It was built using a standard design developed by the Oregon State Highway Department, which became the Oregon Department of Transportation in 1969. The total cost for the original construction of the bridge was $13,155.

In 1925 there were 450 covered bridges in use in Oregon. By 2003, replacement, removal and destruction had reduced that number to 51. Among the survivors, Goodpasture is the longest covered bridge in Oregon still open to vehicular traffic on an active roadway, and the second-longest covered bridge in the state. It is located just south of Highway 126, making the bridge highly visible along this popular east-west travel route.

2. Physical Description of the Bridge

The Goodpasture Covered Bridge is a five-span timber structure crossing the McKenzie River in eastern Lane County, Oregon. The river is one of America's most pristine waterways. It is home to many protected species of aquatic life and is very popular with boaters and anglers. The bridge is a lifeline link providing the only access to a neighborhood of approximately 300 residents. A short approach span from Oregon Highway 126, one of the major east-west state highways, leads to the main span, which is a 50.3 m-long covered Howe truss followed by three simple timber approach spans. The total length is 72.5 m. It is a single-lane bridge that has served to carry logging, recreational, and local traffic. For several years it has been weight-restricted because of structural distress. It still carries approximately 750 vehicles per day, of which approximately 75 are trucks.

Fig. 1 Goodpasture Covered Bridge

Each of the inner and outer leaves of the bottom chords of both trusses are four-piece members. Each of the middle leaves is made from three pieces. Of the sixteen resulting bottom chord splices, eight are broken and were repaired with heavy steel tie-rod and plate assemblies lag-screwed to the timber chord members, first in the 1970s and again in the 1980s. The repairs were only marginally effective. When OBEC Consulting Engineers inspected the bridge in 2010 there were gaps between the ends of timber members at all of the repaired splices, some over 13 mm wide, and the bridge sagged over 100 mm at mid-span.

3. Chronology of Development and Use

The original design was for H-10 loading. However, for many years and especially from the post-war period until the mid-1980s, logging in Oregon was very heavy. For a few years in the late 1970s there was more timber passing through nearby Eugene, Oregon, than through any other city in the United States. A fair amount of it was coming from the McKenzie River valley, and much of that was crossing the Goodpasture Covered Bridge. Traffic across the bridge included many log trucks and other heavy-haul vehicles weighing as much as 360 kN (80,000 pounds) each, four times the design capacity of the structure. Exactly when the bottom chord splices of the bridge trusses began to break is unknown, but the first attempt to repair them was made in the 1970s. Other repairs in the 1980s were part of a major rehabilitation. Yet as recently as 1998 overloads as big as 787 kN, almost nine times the design capacity, were being approved. By 2010 the overall condition had again deteriorated to the point that the state inspection report from that year gave it an overall sufficiency rating of 49 out of a possible 100. That same year the existing heavy composite roofing was replaced with a much lighter cedar shingle roof, allowing the posted weight restriction of 133 kN to remain in effect.

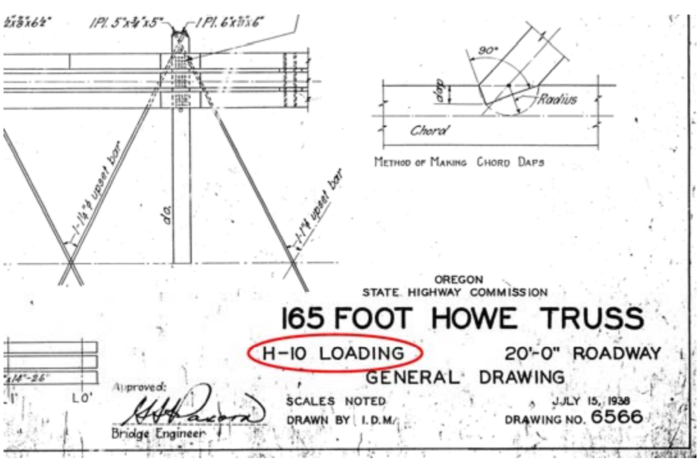

Fig. 2 Oregon Standard Drawing, Howe Truss, 1938

Because of site constraints and concerns of local residents, an alternate crossing was not possible even as a temporary detour. Consequently, all work on the bridge had to be performed under traffic with only short-term night closures. To further complicate matters, the in-water work period recommended by the Oregon Department of Fish and Wildlife is July 1 through August 15. In other words, all work in the active channel had to be complete within a period of only six weeks. In this location the river bottom is rock and over 10 m below the main span. The water here is swift, carrying debris that sometimes includes large trees, and the water level can rise several feet in a few days of heavy rain. Therefore, even if a work bridge or temporary support could be erected during the in-water work period, leaving it in place through a rainy season would be extremely hazardous.

4. Description of Most Recent Rehabilitation Project

4.1 Retuning

Although the bridge was originally designed to carry only an 89 kN live load, it was sufficiently robust that only the bottom chords proved inadequate to carry legal loads. By strengthening the bottom chords, weight restrictions could be removed. However, replacing chord members would not be possible without closing the bridge for an extended period of time, and because this is a lifeline bridge with no serviceable detour route, a long-term closure was not a viable option. Therefore, an alternate load path had to be provided to relieve the bottom chords; the method selected was to post-tension with high-strength steel strand. However, the geometry of the truss had to be corrected before any compression could be applied to the bottom chords or the "repair" would have magnified the sag. The challenge then, in light of access limitations outlined above, was to lift the center of the bridge without any support from below while keeping the bridge open to traffic.

This was accomplished by constructing a pair of tube-steel trusses that fit inside the covered bridge and had sufficient capacity to bear the entire weight of the covered bridge and live loads up to 133 kN. To make room for the steel trusses, 600 mm were cut from each edge of the bridge decking, the bridge rail was removed, and temporary guardrail was installed. The temporary steel trusses bore directly on the concrete piers, narrowing the roadway from 4.9 m to 3.7 m during this phase of construction. This narrowing of the roadway was not a major inconvenience to users as the bridge had always functioned as single-lane; however, this did require additional work at the bridge rail to guardrail transitions.

Fig. 3 Jack on temporary steel truss

Each steel truss was manufactured in three pieces and assembled inside the timber bridge. Then a series of lifting platforms was installed below the floor beams of the timber bridge suspended by steel rods from hydraulic jacks placed on the steel trusses. The timber bridge was lifted 200 mm at mid-span to achieve 100 mm of positive camber. While held in the correct shape by the steel trusses, the vertical hanger rods of the timber bridge were tightened, and the post-tensioning system consisting of six 13 mm-diameter Grade 1200 strands on each side of each bottom chord was installed. Each strand was jacked to 89 kN, yielding a total compressive force of 1068 kN on each bottom chord. This reduces tensile stresses in the bottom chords enough to enable the covered bridge to safely carry legal loads. Then the tube steel trusses were disassembled and removed.

Finally, a new deck was installed, damaged siding was replaced, and the entire exterior of the bridge was repainted.

4.2 Interpretive Display and Lighting

To complete the project, bridge lighting was installed, and an interpretive display devoted to the history of the bridge was added at the top of an existing stairway leading to the river bank at the southeast corner of the bridge.

Fig. 4 Interpretive display

Goodpasture Covered Bridge is located on a blind curve of a heavily-travelled road passing through a dense Douglas fir forest, which is very dark at night. The bridge was difficult to see at night, and there is no turn lane and no shoulder for west-bound traffic. Multiple accidents have resulted from vehicles slowing suddenly to make the turn. Lighting was added to make the bridge more visible at night and to improve safety. High-efficiency LED lights were installed in the windows, under the eaves and behind the barge rafters at the portal ends, activated by an external light sensor and discretely illuminating the ends and side walls from concealed fixtures.

During the past several years local residents have established a tradition of decorating the bridge for the winter holidays. Large wreaths are hung over the portals and colored lights were placed in the windows making them alternately red and green. The bridge owner (Lane County) had reservations about allowing the public to install electric lights on an old wooden structure. To satisfy residents and simultaneously relieve the County of some liability, the window lights were programmed so they can be changed from white to alternate red and green by the flip of a switch located in a locked panel concealed behind a hidden door in the wrap-around siding. The residents can still hang their wreaths and are provided access to the switch at the beginning of the holiday season. The installation is both safe and efficient.

Fig. 5 LED lighting on bridge

Fig. 6 Portal of bridge at night

5. Conclusion

Maintaining the function of the Goodpasture Bridge during the rehabilitation was a key element of the project. The design solution of installing temporary tube-steel trusses made it possible to raise the existing truss elements prior to the installation of the post-tensioning system. This allowed the bridge to remain in use and did not require support from the ground beneath the bridge. All modifications and repairs to the bridge were designed in compliance with the US Secretary of the Interior's Standards for Rehabilitation, preserving the key design characteristics and replacing deteriorated elements in-kind.

Structural augmentation, the post-tensioning system, which allows the bridge to meet required load capacity, was located on the sides of the lower chords below the level of the deck and has minimal visual impact from most accessible viewpoints. The installation of lighting, improving the function of the bridge and reducing the potential for future damage, was undertaken to have minimal visual impact during daylight hours and is entirely removable.

The setting of the Goodpasture Covered Bridge is particularly dramatic and picturesque. It is said to be the most photographed covered bridge in Oregon and is a popular tourist destination. It continues to be a vital resource, functionally, historically and aesthetically.

5.1 Rehabilitation Project Team

OBEC Consulting Engineers – Prime Consultant

DKS Associates – Traffic Study

Heritage Research Associates, Inc. (HRA) – Cultural and Historical Resources

Sea Reach Ltd. – Interpretive Exhibits Design and Fabrication

Balzhiser Hubbard Engineers, Inc. – Lighting Design

Lois Cohen Associates – Public Involvement

David Place Consulting – Construction cost estimating and value engineering