Abstract

In late August 2003, forest fires raged through the hills south of Kelowna, BC. Crews battled the firestorm for two weeks but the fires ultimately destroyed 12 wooden trestles and damaged 2 steel bridges in the Myra Canyon region of the former Kettle Valley Railway. Only months earlier, this section of the Trans-Canada Trail had been designated a National Historic site. Funding to rebuild the structures was secured at both the provincial and federal levels and the rebuilding process began.

The Myra Canyon trestles are situated in the Myra-Bellevue Protected Area, a Provincial Park established in 2001 and managed by the Environmental Stewardship Division of British Columbia's Ministry of Environment. The Kettle Valley Railway, constructed by the Canadian Pacific Railway, ceased to provide commercial service for the region over 30 years ago but continues to provide economic value as one of the most popular tourist attractions in the Okanagan. Recreation corridors are numerous in the region and the Myra Canyon alone attracts over 50,000 visitors each year injecting upwards of $5 million into the local economy annually. While access was limited during construction activities, the trestle reconstruction program continued to draw significant public attention.

Authenticity is a major objective and the trestles are being rebuilt to closely match the appearance of the original structures. The original trestle structures were constructed 90 years ago using local materials framed and partially assembled at Carmi approximately 40 miles east of Myra Canyon. Since then, only two of the 18 trestles have been rebuilt using steel. Reconstruction programs in the late 20's and early 60's used wood as the primary building material and following the wildfires in 2003, the desire was always to rebuild using wood and in a manner that reflected the original designs.

The remote location has presented many of the challenges encountered during the original construction a century ago. These construction challenges and the modern solutions applied to solve them are outlined in this paper.

Introduction

An early morning lightning strike on August 16th, 2003 started a forest fire in Okanagan Mountain Provincial Park that in less than a month would consume 26,000 hectares of land, the majority of 2 Provincial Parks and 270 homes. Myra-Bellevue Provincial Park contains the renowned Myra Canyon segment of the historic Kettle Valley Railway (KVR), designated a site of national historic significance. In early September, 12 of the 16 historic wooden trestles and two steel trestles were destroyed or damaged as the wildfires raced across the Myra Canyon.

Figure 1.

Figure 2. Trestle 13 – September 4, 2003

Decommissioned in the late 70's, the KVR railway corridor is now part of the Trans-Canada Trail and British Columbia's "Spirit of 2010 Trail." Prior to the fire, the Myra Canyon with its trestles and tunnels attracted 50,000 visitors a year providing a significant contribution to the economy of the Okanagan and BC's Southern Interior. The loss of the trestles as both a tourist attraction and a piece of Canadian History was significant. To preserve authenticity, the trestles are being re-built to specifications similar to the original structures. Historic accuracy combined with remote and difficult locations present many of the challenges encountered when the trestles were originally built 90 years ago. These technical and construction challenges follow.

History

The Kettle Valley Railway was constructed by the Canadian Pacific Railway at the turn of the 20th century to move silver and other minerals out of the mines in BC's Boundary-Kootenay region and into Canadian smelters. Completion of the Kootenay-to-Coast railway ensured that rival American rail lines would not be built in the area to haul the ores to smelters in the United States.

The KVR provided regular service for passengers and freight for almost 50 years. Transportation alternatives combined with increasing operating and maintenance costs eventually resulted in service reductions. By 1964 passenger service was phased out, and in the early 1970's operations ceased east of Penticton, with the rails along this section being removed at the end of the decade. By the end of the 80's, freight service west of Penticton was also terminated.

Figure 3. Trestles 17, 16, 15 and 14

Figure 4. Trestle 6

With the railway's abandonment, the Myra Canyon trestles became a popular destination for hikers and cyclists, aided by its close proximity to many well established communities once serviced by the rail line. By 1992, local enthusiasts gathered to create the Myra Canyon Trestle Restoration Society (MCTRS), whose purpose was to maintain the corridor. In 1995 the MCTRS began making the trestles safer for walkers and cyclists by adding new decking and handrails. The right-of-way was incorporated into the Trans Canada Trail and BC's "Spirit of 2010 Trail", increasing its popularity.

The Myra Canyon became a true tourist destination and by 2002 brought some 50,000 visitors from all over the world, contributing up to $5 million annually to the Central Okanagan economy. The canyon boasts breathtaking scenery and easy access from nearby Kelowna. The designation of the KVR as a National Historic site, just prior to the destruction brought on by the forest fire, would prove critical in securing funding and preserving its legacy.

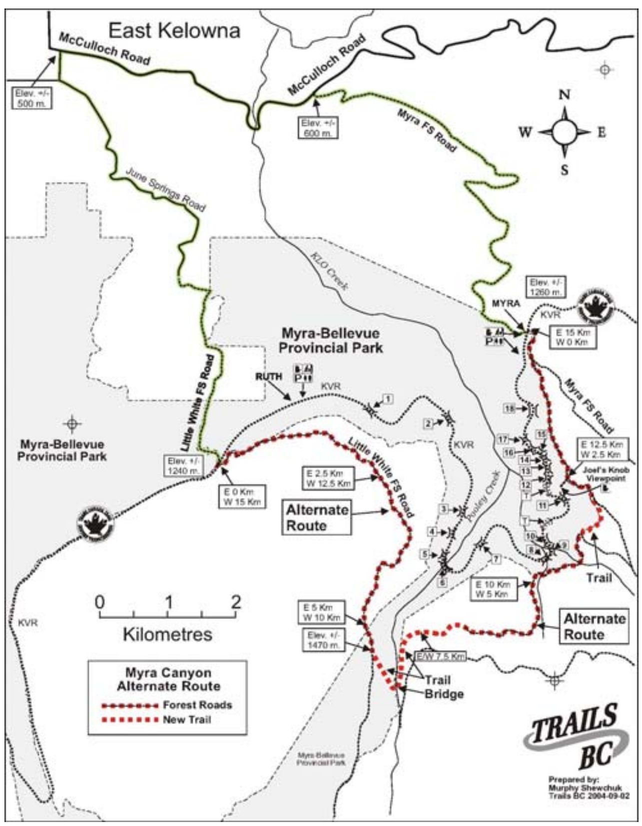

Figure 5. Map of Myra Canyon Trail and Trestles

Resurrecting the Past

Upon learning of the full extent of the devastation to the trestles, support was overwhelming and local, provincial, and federal governments gathered to develop a reconstruction program. While it would possibly have been more economical to simply rebuild the bridges using conventional modern structure types, it was agreed that due to the National Historic significance of the structures, authentic timber trestles would be erected to replace those lost. With funding in place, the reconstruction of the trestles was ready to proceed.

Field Investigation

The most important aspect of producing a new bridge in a modern design environment was getting proper data from the field to the office. The CPR archives provided background information and record drawings of the existing structures, but an investigation of each bridge site was necessary to determine the specific remediation requirements. For practical reasons the use of imperial units was maintained for detailing and therefore dimensions are also presented in that format in this paper.

Figure 6. Trestle 13

Figure 7. Trestle 8

The trestles are located in remote and difficult mountainous terrain and the site conditions vary considerably from one end of the canyon to the other. Trestles 12 to 18 lie on the side of a steep, rocky slope resulting in considerable differences in post length from the uphill to the downhill side. These trestles are generally supported on concrete foundations with intermittent timber mudsills.

Trestles 7 to 11 are constructed on relatively flat surfaces with timber mudsills on loose granular material. Timber cribbing is used to retain loose, unstable slopes.

Trestle 2 is situated on a steep side slope with a combination of loose granular material and fractured rock. Trestle 3 sits partly on the side of the mountain and partly on top of a large timber and rock crib wall that retains small boulder

Figure 8. Trestle 3

Trestle 4 crosses a small canyon and is mostly supported on timber piles driven into the softest material found along the line. It is also the tallest timber trestle at 130 feet high and is over 500 feet long.

The first step of the field investigation was to determine the trestle horizontal and vertical alignment by locating the remains of the existing posts. A survey crew was sent out to obtain coordinates and elevations for each post. The results were compiled into a 3-D survey model that provided the basis for the geometry of the new trestles.

The next step was to determine the suitability and stability of the existing foundation locations for the construction of a new structure. It was noted during the field investigation and survey that most of the foundation locations were suitable for a replacement structure.

Concerns included:

- A timber crib wall at Trestle 15 badly burned by both the fire and fire-fighting activities had failed, undermining a nearby concrete foundation as well as compromising the slope stability near several proposed timber mudsills.
- A timber crib wall at Trestle 11 was both decaying and burned. The integrity of the crib relative to the steep terrace was in question.
- Most of the piles at Trestle 4 had burned completely to ground level and the suitability of the piles for re-use to support a new structure was in doubt.
- The outside crib wall face at Trestle 3 had been incinerated. The integrity of the material that the crib wall had retained was a concern.

Figure 9. Trestle 4

Other than the concerns raised at these trestles, the majority of locations were found to be suitable for the new structures. Trestles 6 and 9 were constructed of steel and had not suffered significant structural damage. These structures only required replacement of the timber decking and handrails. Trestle 5 is the smallest of all the structures at 75 feet long and 10 feet high, and replacement was straightforward. A full condition survey log was compiled, with recommended remediation actions at each location. The detailed design proceeded using the information obtained during the field investigation.

Design Criteria and Challenges

The objective of the trestle reconstruction was to create new structures that would be authentic and would resemble the appearance of the original trestles. It was recognized that building exact replicas was not required due to design loads being significantly less than railway traffic. Various post configurations were considered and two templates were created: a 4-post, 15-foot span design for greater authenticity and a cost-effective 4-post, 30-foot span design for structures that would not be easily viewed from the opposite side of the canyon and for those that were not located adjacent to undamaged trestles. Trestles 4 and 7 were located directly across the canyon from each other and are clearly visible. To preserve the original aesthetics, these were designed with the 15-foot span design. Trestles 13, 14, and 15 were given similar treatment not only due to their visibility from Trestle 2, but because of their close proximity to Trestles 12, 16, and 17, which survived the fire. Trestles 5 and 8 are to be reconstructed with 15-foot bays. Trestles 2, 3, 10, and 11 are less visible from other locations in the canyon and were designed with the 30-foot bay configuration.

The new trestles are designed to permit a fully loaded concrete truck (56 kips) to pass over the structure in order to reach other reconstruction locations. Maintenance vehicles are anticipated to be the heaviest loads crossing the trestles after construction.

Significant new design criteria were adopted to meet the Canadian Highway Bridge Design Code. The result was more stringent design requirements than the last reconstruction of the trestles by the CPR in 1958-1962. In particular, wind loading dictated much of the foundation design on the taller structures. While it was clear that wind loadings had not been an issue previously (as evidenced by the fact that none of the trestles had ever blown over), the analysis of the new trestles indicated that the new structures would require more substantial foundations to resist both horizontal and overturning forces induced by wind loading. In the past, the regular passage of trains over the bridge would re-position any members displaced by the wind (if it occurred at all).

The obvious choice of foundation material for addressing uplift was concrete, using its dead weight to anchor the structure. The difficulty in using concrete was delivery and placement at the remote site locations. While concrete could be delivered to site by truck, transportation was long and placement was awkward. It could not be delivered by hand from the truck to the foundations because of the terrain, and using a boom pump was not feasible for the locations where the concrete was typically needed. Concrete foundations were costly and they were used only when no other foundation option was practical.

Another issue that proved to be a challenge was the design of replacement handrails. Structural analysis showed that the handrail design used on the previous structures was inadequate under the new code. In fact, developing any design that would meet code was proving difficult with the geometry of the connecting members and the material involved. If the material had been steel or concrete, designing an adequate handrail would have required little effort. Attempting to connect a timber post to a tie using the moment couple of through bolts without using knee bracing was resulting in solutions that were either expensive (ordering wider ties) or unattractive (a steel plate running halfway up the post). The final solution was simple, preserved the aesthetics of the railing without running up significant costs, and provided an excellent option for retrofitting the undamaged trestles as well.

Trestle 4, with its piled foundations, made for an interesting challenge. The condition survey of the piles showed that a significant number of them were decaying, and that replacement piles would be necessary. Installation of new timber piles using conventional means was not practical. The contractor could not install new piles as the bridge progressed because a) the rig would not be able to reach out horizontally far enough to reach the bottom of the tallest bents (70 feet wide at the base) and b) keeping a piling rig on site to work only one day a week for 4 months was not economical. The terrain of the area also precluded use of a piling rig for installing piles in advance of trestle construction. The solution was to use micro piles that provide the required capacity without requiring large equipment. All major equipment could be set up at an abutment, and hydraulic lines could be run to the drilling apparatus at each location. Because of the slender nature of the micro pile, and the fact that many of the piles extended several feet above ground level, the piles were sleeved above ground level and grouted solid to improve the pile stability.

Trestle 11 faced a similar difficulty where the timber cribbing was decaying and damaged. The prospect of rebuilding the crib wall using hand tools was considered to be too difficult on the steep embankment and the fill was not considered stable enough to support the proposed bent. Again, micro piles were the solution best suited for this situation. The piles would take the load off of the fill, and the fill would provide stability to the piles.

Access Challenges

Construction access to the trestle sites in the Myra Canyon was limited in the early 1900's and through the entire period that the CPR operated the KVR. During the original construction period several tote roads were in use to bring supplies to the active work sites. While some remnants of these 90 year old trails can be found, they remain largely overgrown and are not practical for use by the vehicles and equipment necessary at the reconstruction locations.

Figure 10. Rock Oven – Built 1910-1915

The "end of track" was a moving community during the original construction and some rock-ovens used by the workers still remain. Supplies that were not brought to the end of track along the tote roads were brought by rail from yards in Midway or Penticton.

During the period that the KVR was operating in the Myra Canyon, regular maintenance was required on the wooden trestles, the steel bridges and the tunnels. The railway had equipment that operated from the track level and even entire trestles were rebuilt without causing significant delays to running traffic. Temporary foundations were sometimes constructed to support train operations while new concrete or timber foundations were being installed. All these maintenance and reconstruction activities were simplified by the rail access that existed from 1915 to 1980.

Today, all materials are trucked in following rough forestry roads that are very difficult to navigate with 45ft trailers and 45t timber payloads. Once the 3000 ft elevation gain from Kelowna is completed the trucks continue along the remaining railway grade to the contractor's staging area near the site of the former trestle structure.

Due to the limited site access, the number of trestles that can be constructed at one time is limited to two – one at either end of the canyon. The trestles were grouped into two construction tenders – one tender for the construction of east side of the canyon near the former Myra Station siding and one tender for the construction of trestles on the west end of the canyon near the former Ruth Station siding.

Figure 11. Concrete delivery to trestle 11

Construction Challenges

Contractors faced significant construction challenges due to the difficult locations and limited access. Rubber tired and tracked cranes were used to assemble the timber components of the trestles for the majority of the contractors. However, two trestles were constructed using high-lines to ferry materials into the site from its staging area.

Figure 12. Tracked crane on trestle 14

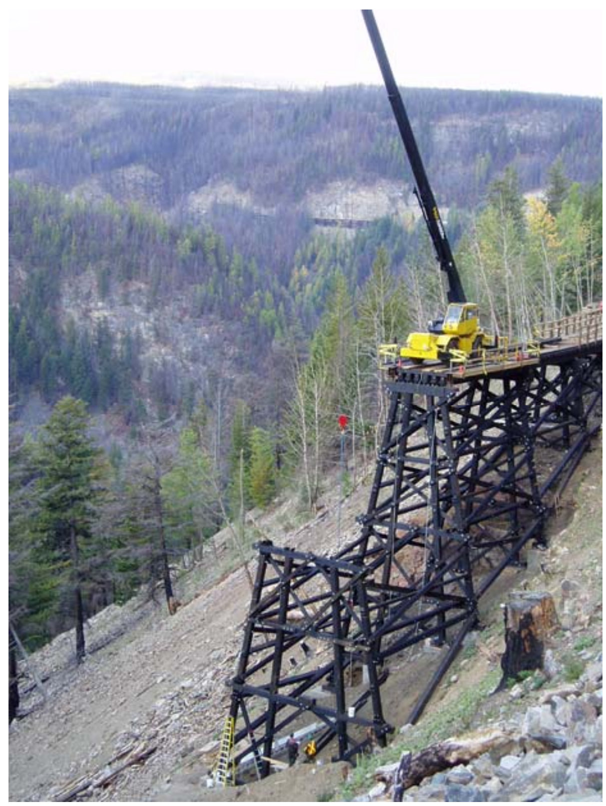

Figure 13. Rubber tired crane on trestle 11

Figure 14. Highline on tangent trestle 2

Figure 15. Highline on curved trestle 4

The contractors working on the reconstruction of the Myra trestles faced a number of challenges that were unique to the project's location and limited access.

Challenge:

- Construction of concrete foundations where no concrete foundations previously existed.

Impact:

- Approximately 400 cubic yards of concrete were required for foundations. Concrete was either placed by helicopter or by inline pump.

Figures 16, 17.
Placing concrete by helicopter at trestle 11

Challenge:

- A very small work area at the trestle. Bents pre-assembling into structure components at staging area.

Impact:

- Crane or highline was used considerably for handling timbers during bent assembly.

Figure 18. Assembling bent with highline at trestle 2

Figure 19. Placing bent sections with crane at trestle 11

Figure 20. Delivering bent sections to trestle 15 from staging area

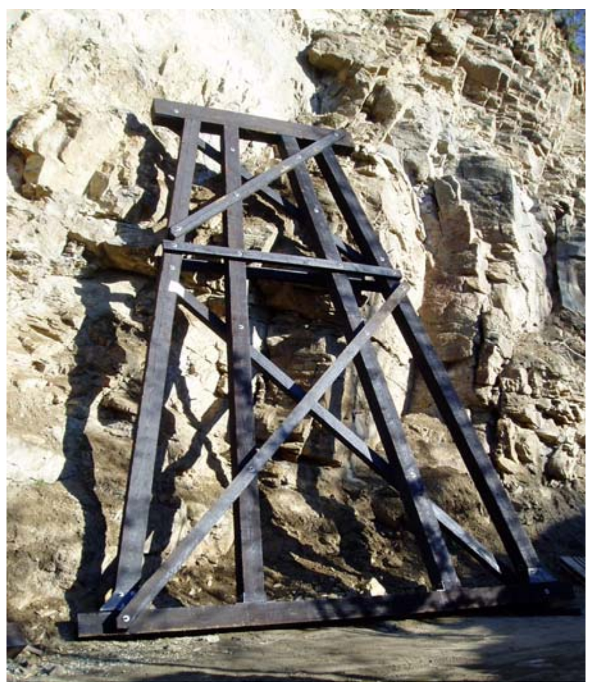

Figure 21. Prefabricated bent sections for trestle 4 in staging area

Challenge:

- Existing timber piles destroyed at trestle 4 and limited equipment access.

Impact:

- Micropiles and concrete pile caps were incorporated into foundation design.

Figures 22, 23, 24, 25. Trestle 4 required the installation of over 150-25' long micropiles – all placed using portable equipment

Figure 26. Trestle 15 burning

Figure 27. Reconstructed Trestle 15

Figure 28. Trestle 13 burning

Figure 29. Reconstructed Trestle 13

Figure 30, 31. Reconstructing Trestle 10

Figure 32, 33. Reconstructing Trestle 11

Final Comments

The original trestle structures were constructed 90 years ago using local materials framed and partially assembled at Carmi approximately 40 miles east of Myra Canyon. In the 90 years since then, only two of the 18 trestles were rebuilt using steel. Reconstruction programs in the late 20's and early 60's used wood as the primary building material and following the wildfires in 2003, the desire was always to rebuild using wood and in a manner that reflected the original designs – the desired outcome was achieved.