INSTALLATION OF BRAZILIAN HARDWOOD TIES IN 8-MILE CASCADE TUNNEL ON BNSF

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Abstract

Burlington Northern and Santa Fe Railway (BNSF) utilized a P811 track renewal machine to install approximately 5,700 Mora wood ties in the 7.8 mile Cascade Tunnel in Washington State during August 2002. The scope of the project included the replacement of oak crossties, restoration of proper clearances, and rehabilitating the drainage system in the effected areas.

The History of Cascade Tunnel

In 1925 the Great Northern Railway undertook the task of designing a new route, including a long tunnel, through its highest points within Washington State’s Cascade Mountains. The planned alignment would reduce the route length by 11.0 miles. The new line would include the construction of a 7.8 mile tunnel. At that time, the longest tunnel in North America.

The construction of the new Cascade Tunnel began in 1925, and was completed 3 years and 47 days later.

The internal gradient of the tunnel is 1.7%. The elevation of the East Portal is 2894 ft. above sea level, with that of the West Portal being 2247 ft. The entire length of the tunnel is tangent.

Electric locomotives originally operated through the tunnel using overhead power that the Great Northern produced from nearby rivers by building hydroelectric dams. A forced air ventilation system was constructed at the East Portal in 1956, thus allowing the use of diesel locomotives. The addition of the fanhouse eliminated the need for train crews to switch out the head end power from diesel to electric, then back to diesel.

Methodology

Drainage is always of paramount concern in any tunnel. The Cascade Tunnel is no exception. Due to leaks that developed in the original concrete liner, aggravated by crown cutting that took place in 1984 to accommodate double stack container traffic, there are several areas of the tunnel where the track structure remains saturated at all times. Water that leaks into the tunnel travels down gradient in trackside ditches to cross drains that flow south approximately 75 ft. to the smaller Pioneer Tunnel. The Pioneer Tunnel was
excavated adjacent to the westernmost three miles of the Cascade tunnel in order to expedite construction. Today the Pioneer serves as a drainage way carrying away an estimated 85% of the water that infiltrates the Cascade Tunnel.

In the past, ties had been replaced in the tunnel using various methods. The width of the tunnel does not permit a tie extractor to remove a full length tie. Therefore, the previous tie programs had taken a significant amount of time and had been very labor intensive. The most common replacement method involved removing the fouled ballast material between several adjacent ties, sliding the ties together, and then rotating each one parallel to the rails so that it could be removed. The new ties were placed underneath the rails using the opposite process. Depending on the amount of track time that was available, the work could last for months. Regardless of what process was used, rarely were the ties replaced out of face. Also, sub-grade conditions were generally not addressed at the same time that the tie renewal took place.

It was agreed upon in 2000 that due to tie and ballast conditions, a rehabilitation program needed to take place at each end of the tunnel where the conditions were the worst. The project was then scheduled for August 2002 using the BNSF P811 concrete tie installation machine.

A year previous to the Cascade Tunnel project, BNSF had undertaken a similar program in two smaller tunnels. These tunnels, the Winton and Chumstick, were much shorter than the Cascade tunnel, and did not present as many logistical problems. Many lessons were learned that in turn, helped the Cascade Tunnel job run more smoothly.

The two smaller tunnels received standard #5 oak ties that were pre-plated with elastic fasteners. However, for the Cascade Tunnel application, BNSF opted to install Mora wood ties supplied from South America, rather than conventional oak. It was felt that the life of the Mora tie would be longer than that of an oak, given the harsh environment.

The dimensions of the Mora tie offer a significant advantage over those of standard oak. The mora ties installed were five inches thick, compared to the seven inch thick oak tie. Therefore, if the bottom of the ties remained at the same level, a two inch gain in clearance would be immediately realized. The “footprint” of the mora tie is also 10% larger in area than the oak. This contributes to a more stable track structure throughout the soft sub-grade conditions.

The ties were received at the Port of New Orleans. They were then inspected and transported to a contractor to perform the boring and pre-plating operation. Conventional cut spikes and rail anchors were chosen over elastic fasteners based on the caustic environment inside the tunnel. The ties were then plated, banded into bundles, and shipped to Skykomish, Washington in order to be transloaded onto the P811 flat cars.

The Process
Existing elevation and alignment conditions of the track to be rehabilitated had to be identified prior to any work taking place. Horizontal offsets between the outside of the rail and the face of the wall were measured and recorded. Existing top of rail levels were projected onto the adjacent wall using a laser level. The resultant laser point was painted, measured, and logged. Most of these readings were taken at 100 ft intervals. However, measurements were also taken in and around critical areas such as signals and electrical conduits. Horizontal clearances were especially tight in these locations due to apparatus that is attached to the side of the wall and protrudes toward the track.

After the elevation and alignment data was collected, the ditches were stripped in two different stages prior to any P811 work taking place. A production shoulder cleaner was leased specifically for this purpose. The initial pass removed the shoulder material down to a level even with the bottom of the existing ties. At this point, there was no material between the ends of the ties, and the wall. The second pass, taking place two working days ahead of the P811, then lowered the level of the cut to roughly three inches below the tie. Drainage was maintained throughout the ditching process. Since no shoulder existed, increased track inspection took place after the second shoulder cleaner pass was completed. However, no surface quality issues were noted that may have been aggravated by the shoulder removal. Since the temperature inside the tunnel remains essentially constant at all times, tight rail conditions were not of particular concern with no shoulders in place.

All of the waste material that was produced from the shoulder cleaner was discharged into a slot train. Once the slot train was loaded, the consist moved outside the tunnel, off of the main track, and stockpiled the material. The total amount of waste material removed from the project was approximately 3,400 tons. Samples of this material had previously undergone laboratory analysis. The results of the tests indicated a petroleum presence slightly higher than the threshold for standard fill material. Therefore, all of the material removed from the tunnel was stockpiled, transloaded into open top containers, and disposed of at an approved landfill facility.

Once the shoulder material had been removed, the P811 could then begin laying the new Mora ties. A hy-rail vacuum truck was used to remove the material from between ten consecutive ties in order to provide enough room for the P811 to be cut into the track at the beginning of each days work. Once the machine was in the track and operational a large amount of fouled ballast was displaced to the area between the end of the ties, and the wall of the tunnel that had been previously excavated by the shoulder cleaner. This allowed the new ties to be laid at the lowest possible elevation.

After the P811 machine had placed the pre-plated Mora ties onto the top of the prepared sub grade, the rail was re-installed. During the pre-plating procedure, the inside rail spike was left protruding approximately 1-1/2” above the plate. This allowed the base of the rail to align itself with the rail seat in the tie plates before being forced downward by the machine. A field side rail spike was then driven by hand every tenth tie to ensure that the rail, if not seated, would not lose gauge underneath the machine. A pup tamper directly behind the P811 then tamped the ties tight to the rail. Since conventional fasteners were
being utilized, typical rail relay equipment then finished spiking the ties, and applying anchors.

When the P811 was finished each day, very close track surface measurements were taken to be certain that the track met BNSF criteria. Since the top of rail level was being lowered an average of three inches, a run up had to be made in the zone from new to old ties. This transition was accomplished by placing ballast in the tie cribs, raising the track with hydraulic jacks, and tamping the ties with the pup tamper. A second work train was then used to dump ballast in the center of track. There was no dumping of ballast to the outside of the rails since the ditches were full of the waste material generated by the P811 cutting chain. Surfacing equipment then corrected any excessive cross level that would cause double stack container cars to violate the clearance envelope.

The following day, the P811 would be placed into the track some twelve ties short of the point that it had been removed the previous day. Normally, the machine starts at the exact location that it finished the previous working day. However, since the top of rail elevation was so critical, this practice was observed in order to ensure that the track was not raised by the P811. Once the machine was in the track, the twelve new ties were removed and later placed back onto the P811 flatcars for re-installation.

After the ties were installed and the initial surfacing completed, the shoulder cleaner and slot train were utilized once again. Two passes were made to remove all of the fouled material that had been discharged into the ditch area by the P811. The second pass removed all material to a level just below the bottom of the new Mora ties. Once again, this material was off loaded and stockpiled outside the ends of the tunnel for later disposal. The surface correction crew then completed the final surfacing.

**Safety**

Working inside tunnels, as well as any confined space requires additional planning where safety is concerned. There were several areas that needed to be addressed prior to the start of the project to ensure that the tie renewal process was performed safely. The primary issue dealt with air quality. With multiple locomotives, as well as several high output diesel engines operating, the emission levels could have quickly become hazardous had appropriate measures not been implemented. During normal train operations, the emissions are forced downgrade from East to West by using two high output electric fans located at the East Portal. Each of these fans is capable of generating 250,000 cubic feet per minute. It was determined from air velocity testing that only one fan would likely need to be operated during the P811 operations, thus allowing the second fan to serve as an emergency backup.

The maintenance crews were arranged to work in a westerly direction. This was not only done to work down grade, but more importantly most workers were located at the rear of the machine, and therefore were subject to a lower level of emissions. All employees working inside the tunnel were fit tested for, and issued cartridge type respirators to utilize, if they so desired. A representative from the Industrial Hygiene Department was
on site for the early stages of the project to monitor both the air quality and noise levels inside the tunnel. With one vent fan in operation the air quality measurements were in fact below any dangerous thresholds, as was predicted.

Lighting within the project area was also a worry. Previous to any tie renewal work taking place, electricians purchased and strung approximately three miles of lighting. The light cable was placed high enough in the tunnel as to not interfere with the clearance envelope. These light strings consisted of white bulbs of 200 watts each placed every 50 ft. Secondary lighting, such as headlamps, headlights, and flashlights was still required to perform basic work activities.

Employees also had to be very aware of close clearances. The P811, when in the work mode, is wider than a normal freight car. There are various platforms and operator seats that must be folded down while installing ties. The rail, while in the working mode, is wrapped around the outside of the machine. This resulted in a very tight clearance between the rail and the wall of the tunnel, usually preventing anyone from passing between the wrapped rail and the wall.

There were areas of the tunnel that produced closer clearance than others. When the crown cutting took place, the track alignment was not necessarily centered in the tunnel. The notches in the liner were cut according to where the track was laying at the time. In some areas, the track, and corresponding notches, were as much as one foot closer to the south wall. Unfortunately, the track cannot be centered without re-cutting the crown.

An action plan was also developed to handle any emergency evacuations. At any one time there were up to eighty five people in various locations throughout the 7.8 mile tunnel. Communication took place through the use of a radio channel unique to the tunnel. However, this system was out of service for approximately two hours on one day, essentially making it impossible for radio communications over distances greater than 200 ft.

**Issues Encountered**

Even though an extensive amount of planning and preparation took place well ahead of the start of the project, problems were encountered that required corrective action. The most costly problem, as far as the production rate was concerned, was the length of the ties. The standard length of the Mora ties installed was 8'-6”. The BNSF standard concrete ties that are typically installed by the P811 are 8’-3” long. The machine can accommodate ties up to a length of 8’-6”. However, a percentage of the Mora ties were slightly longer than the 8’-6” dimension. Ties that were just 1/2” too long had difficulty negotiating the conveyor system. If the ties were not exactly centered, one end would often catch the frame of the inclined conveyor, and skew all of the ties above it. Once these jams occurred, employees would have to straighten the ties out using lining bars. These numerous tie jams would take an average of five minutes to clear. However, this issue was solved after the third day of the project by fabricating and installing guide
system consisting of rollers installed along the conveyor. Soapy water was also applied to the ends of the ties to reduce the chances of becoming skewed if they were too long.

The travel time for the P811 consist caused some undesired loss in productivity. After the P811 work was completed each day, it was moved out the West Portal of the tunnel, and eight miles down the 2.2% grade to Skykomish, WA. There is a controlled siding at each end of the tunnel. However, these sidings had to remain clear in order to aid in train operations. All smaller equipment, such as pup tampers, spikers, and anchor machines, were moved outside of the East Portal where they were removed from the track using a large rubber tired crane. This operation saved the small equipment from traveling approximately eight miles down a 1.8% grade, and back up the same grade the next morning. The safety of the project was also enhanced by not allowing this small equipment to travel long distances on the steep grades.

**The Final Product**

To date, the two segments of track that were renewed with the Mora ties have held surface very well. There has been some minor surfacing that has taken place since the project was completed. However, overall the track quality within the area of the project is still very high. There have been several geometry car trips through the area with no exceptions taken.

The ditches through the work area remain open and flowing. However, some of the short mud areas have reappeared in the track since the renewal took place. However, these areas do seem to hold surface better, most likely due to the larger footprint of the mora ties.

The vertical clearances that were extremely tight previous to the project have been restored to a more comfortable level. There is now enough room for surfacing to take place without violating the clearance envelope.

Even though the costs associated with the project were fairly high, the final product was of much higher quality, and lower cost than any other method had produced in the past. BNSF is planning on rehabilitating the next segment of the Cascade Tunnel in 2005 using this same process.