Seminar Paper

PILE TRESTLES

on

Logging Railroads

by

J. S. Brandis
PREFAE

Of the average railroad, trestles constitute from one to three percent of the total length. In railroad logging in the Pacific Northwest today this percentage is much greater. In years past the logging companies had more of a selection of shows which they could log. It was not necessary at that time to reach far back into the hills, where the terrain was rough, to acquire a high grade of timber. While today with the better shows logged off, they must withstand costly construction due to terrain features, in order to log the finer virgin timber.

Many times the engineers find it less costly to build a pile trestle, rather than to fill some of the wide, deep ravines, or to construct railroad many miles around the head of the said ravine.

It is this single principle, "cheaper cost of construction", that has made the pile trestle so popular in logging railroads. The comparatively short time the trestle is in use would not grant the construction of a permanent steel bridge, or a costly fill.

The pile trestle most widely used on logging railroads is known as the "five-pile-bent" trestle. This is due to the heavy loads that are frequently passing over these trestles.

This paper will endeavor to explain the construction, and comparative costs of the pile trestles.
GENERAL

Generally pile-bents are used where the ground is quite soft, and where the distance from the ground to the rails is not too great. The one grave objection to the high pile-trestles is that the top end of the pile is in the ground. The top is of the poorest timber and decays more readily than the other timber.

Piles should be at least from 12 to 15 inches across the butt after being cut off.

The requirements of a pile are:

1. Straight
2. Sound
3. Live heart timber
4. Free from wind-shakes
5. Free of cracks, worm-holes, and all description of decay.
6. Free of large, loose, black or decayed knots.
7. It is much preferred to have the piling stripped of the bark.

The timber used for piling depends largely upon the kind growing in the immediate vicinity.

The following are listed in the order of their durability:

1. Red cedar
2. Red cypress
3. Pitch pine
4. Yellow pine
5. White pine
6. Redwood
7. Elm
8. Spruce
9. White oak
10. Post oak
11. Red oak
12. Black oak
13. Hemlock
14. Tamarac

The timber used for trestles in the Pacific Northwest is red cedar, Douglas fir, and hemlock. The average life of the cedar trestle is 15 to 20 years, the Douglas fir, 8 to 10 years, and the hemlock, 3 to 6 years. The variation in the life of the bridge is mainly due to the use of the trestle, and the climatic conditions in that area.
1. **TRESTLE.** A braced framework of timbers, piles, or steelwork, for carrying a road over depression.

2. **PILE TRESTLE.** A structure in which the upright members or supports are piles.

3. **BENT.** The group of members forming a single vertical support of a trestle, designated as a pile bent where the principal members are piles.

4. **BATTER.** The deviation from the vertical in upright members of the bent.

5. **CAP.** The horizontal member upon the top of piles, connecting them in the form of a bent.

6. **SWAY BRACES.** Members bolted or spiked to the bent and extending diagonally across its face.

7. **LONGITUDINAL STRUTS OR GIRTS.** Stiff members running horizontally from bent to bent.

8. **SASH BRACES.** Horizontal members secured to the posts or piles of a bent.

9. **STRINGERS.** The longitudinal members extending from bent to bent and supporting the ties.

10. **JACK STRINGERS.** A single line of stringers placed outside the main stringers.

11. **TIES.** Transverse timbers resting on the stringers and supporting the rails.

12. **GUARD RAILS.** Longitudinal members, either iron or wood, secured on top of ties.

13. **PACKING BLOCKS.** Small members, usually wood, used to secure the parts of a composite member in their proper
14. PACKING SPOOLS OR SEPARATORS. Small castings used in connection with packing bolts to secure the several parts of a composite member in their proper relative position.

15. DRIFT BOLTS. A piece of round or square iron of specified length, with or without a head or point, driven as a spike.

16. DOWEL. An iron or wood pin, extending into, but not through, two members of the structure to connect them.

17. SHIM. A small piece of wood or metal placed between two members of a structure to bring them to a desired relative position.

18. FISH-PLATE. A short piece lapping a joint, secured to the side of several members which are butt-jointed.

19. BULKHEAD. Timber placed against the side of an end bent for the purpose of retaining the embankment.
Trestle Construction

ENGINEERING. In trestle construction the engineering work consists of the preliminary work and location of the trestle, making the plans for the trestle, and the inspection and supervision of the construction.

PRELIMINARY. Upon indication that a trestle will be needed, the engineer runs the center line of the trestle across the ravine. Levels are then run along the center line to determine the percent of slope of the bridge, and the percent of slope at each fifty foot station.

BRIDGE PLAN. With the data collected, a profile of the ravine is then drawn up. Such a profile will include the height and station of each bent. With this profile, the engineer then stakes out the location for each bent.

This profile furnishes the basis for an estimate of the quantity of piling, caps, stringers, ties, bracing and iron needed to complete the trestle.

INSPECTION AND SUPERVISION. Upon the beginning of the construction of the trestle, the engineer must see that the trestle is built to the required specifications and standards.

His duties are:

1. Line up bents.
2. Plumb bents from side of trestle.
3. Spot and line up piling in bent when being placed for driving.
4. Test pile for bearing while being driven.
5. Determine cut-off point on bent.
6. Record pile bearings and penetration.
7. See that proper number and length of bracing is used.
8. Set center line points on caps for deck placing.
9. Check for proper laying of stringers.
10. Set center line on ties for laying of steel.
The parts of a trestle are classified under two main heads; namely, the "sub-structure" for that part which is below the deck, and "super-structure" for all which is above the caps.

The "sub-structure" includes the piling, caps, sway-braces, sashes, towers, girts, and diagonal braces.

In the "super-structure" are included the stringers, ties, guard rails, and often barrel platforms and walk ways.

The most common pile trestle in logging is the five-pile-bent trestle.

**PILES.** The center pile or plumb pile is driven straight down on the center line of the trestle. To either side of the plumb pile are the track piles, which lean toward the plumb pile with a slope or batter of one inch per foot of height of the pile. The outer piles, or batter piles are sloped inward with a batter of two inches per foot of height of the pile.

Example: If, at the top, the centers of the piles were spaced thirty-two inches apart, and the trestle height was seventy-five feet, the center of the track piles would be 107 inches from the center of the plumb pile. The center of the batter piles would be 182 inches from the center of the plumb pile.

**CAPS.** Caps are timbers laid across the top of the five piling of a single bent. They are fastened to each pile with drift bolts. Caps are usually 12" x 12" x 14" or 12" x 14" x 14". It is upon these caps that the stringers are placed. The caps allow an equal distribution of weight.
BRACING. Bracing is used to support the bents of the trestle against lateral and side motion when under a load. Most commonly used are 3" x 10" boards varying in length with their position on the trestle. The grade most commonly used is number one common.

SWAY BRACES. Sway braces are diagonal braces between the sashes on the bent. The sway braces on the front of the bent run diagonally from the left downward to the right. The front of the bent being toward the origin of the bridge. Often on high bridges it is necessary to put double sways between lower sashes. As the name implies, the function of the sway braces is to prevent sideward motion of the bridge as a load is passing over it. They are fastened with boat-spikes.

SASH BRACES. Sashes are fastened horizontally across the front and back of the bents at the interval of every eighteen feet in height. They also are fastened with boat-spikes.

The longitudinal braces of a trestle are the girts and towers.

STRINGERS are timber spanning the openings between bents. Size, number, and arrangement vary. Usually span at least two openings. In logging trestles usually hewn logs are used.

Arrangement of stringers fall into two classes; "chorded" and lapped.

CHORDED DECK. The stringers lay parallel -- end of one butted against the one immediatly before and immediatly
after it. Three on each side or six across each opening. When light stringers are used an extra one, "jack stringer", is placed outside just below the guard rails.

The chorded stringer arrangement is superior in that it lies directly under the rails and also that it supports the bridge longitudinally. However, this type costs nearly double of what lapped deck costs.

**LAPPED DECK.** The stringers are not butted but angled off the rail line. Only two stringers are under each rail or four across each opening. Span two openings. Stringers are usually 12" x 18".

**TIES.** Most common are 8" x 8" x 10' and are placed on stringers at right angles to the center line of the trestle. Spacing is often 8" apart but 6" is much preferred.

**GUARD-RAILS** are fastened to both ends of the ties. Usually use 6" x 8". If 6" x 8" are used they leave 5" above the top of the ties. Often placed on top of ties near ends then use 4" x 4".

For two purposes -- to prevent as best possible the derailed rolling stock from leaving the trestle and to keep ties in place.
SHOWING SUPER-ELEVATION OF OUTER RAIL AS USED ON CURVES
Contract and Costs

The following are the contract and costs of a bridge actually put in by one of the logging companies in north-western Washington.

The timbers used for the piling on this bridge are Douglas Fir.

Due to unforeseen difficulties this bridge cost the contractor much more than he had anticipated. It also took him nearly three times as long to complete the trestle as he had estimated.

As many of the trestles in the logging business are contracted this example is being included in this thesis to give the reader some idea of a practical contract and cost forms kept by the company.
This is to confirm oral contract made with you this first day of June, 1936, by which you have contracted to build for us three bridges on our logging railroad located in Sections 29 & 32, Township 15, Range 7 W. W. M., as per profile and other information on file at our camp office, as follows:

**Bridge One (1)**

You agree to furnish all labor for the purpose of yarding out the bridge-site as per plats and profiles and your examination of the site, and you will fall and yard the necessary piling from timber near the site and also yard out necessary material for stringers and caps. You will hule all stringers and caps. You will haul the bracing now piled along our mainline track to the site, and drive the bridge according to plans and profile and under the supervision and direction of our construction engineer.

We will furnish and deliver to the bridge-site our pile driver in usable condition, together with necessary blocks, lines and other equipment. We will rig up a spar tree for the purpose of yarding out the bridge-site and will furnish and deliver to the site our 125 H. P. Clyde gasoline donkey with suitable lines and rigging.

Upon completion and acceptance of the bridge, ready for ties, we will pay you $6.00 per running bridge-foot, plus $425.00 for preliminary work such as yarding out site, yarding piling, and delivering bracing to the site.

**Bridges Two (2) and Three (3)**

It is understood and agreed that you will build these
two bridges according to plats and profiles to be furnished and under the supervision and direction of our construction engineer.

You will cut and deliver to the respective sites all necessary piling and deck material and drive and build and brace these bridges for the amount of $4.75 per running bridge-foot complete.

We are to furnish necessary pile driver and equipment and brace material. Upon completion of this contract you are to return all equipment furnished you, in as good condition as when received, ordinary wear and tear excepted.

Payment for the construction of any one of the three aforementioned bridges shall be made to you upon completion and upon satisfactory evidence that all labor and/or industrial insurance and medical aid and/or materials have been paid, or are to be paid by us, in which latter case such payment shall be deducted from the amount due you.
<table>
<thead>
<tr>
<th></th>
<th>3 x 10</th>
<th></th>
<th>Ties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bridge Bracing</td>
<td>Boat Spikes</td>
<td>Ties</td>
</tr>
<tr>
<td></td>
<td>$572.43</td>
<td>$27.23</td>
<td>$228.84</td>
</tr>
<tr>
<td>Freight</td>
<td>15.00</td>
<td>17.80</td>
<td>15.00</td>
</tr>
<tr>
<td>Freight</td>
<td>25.65</td>
<td>26.70</td>
<td></td>
</tr>
<tr>
<td>Freight</td>
<td>168.79</td>
<td>18.15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$796.37</td>
<td>9.28</td>
<td>$243.34</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$124.37</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Payroll</th>
<th>Industrial Insurance</th>
<th>Medical Aid</th>
<th>Social Security</th>
</tr>
</thead>
<tbody>
<tr>
<td>$47.10</td>
<td>$4.84</td>
<td>$0.42</td>
<td>$0.99</td>
</tr>
<tr>
<td>11.12</td>
<td>1.18</td>
<td>0.11</td>
<td>0.23</td>
</tr>
<tr>
<td>$58.22</td>
<td>$6.02</td>
<td>$0.53</td>
<td>$1.22</td>
</tr>
</tbody>
</table>

Pullars account --- Direct

<table>
<thead>
<tr>
<th>Payroll</th>
<th>Industrial Insurance</th>
<th>Medical Aid</th>
<th>S. S.</th>
<th>Personal Account</th>
</tr>
</thead>
<tbody>
<tr>
<td>$734.26</td>
<td>$68.96</td>
<td>$5.79</td>
<td>$15.42</td>
<td>$45.05</td>
</tr>
<tr>
<td>807.90</td>
<td>111.06</td>
<td>11.25</td>
<td>20.42</td>
<td>1.52</td>
</tr>
<tr>
<td>164.68</td>
<td>88.98</td>
<td>8.58</td>
<td>18.33</td>
<td>29.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>75.00</td>
</tr>
<tr>
<td>872.81</td>
<td>106.50</td>
<td>10.96</td>
<td>22.61</td>
<td>28.23</td>
</tr>
<tr>
<td>1077.11</td>
<td>$375.50</td>
<td>$35.68</td>
<td>$76.78</td>
<td>106.64</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>77.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>67.55</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$431.72</td>
</tr>
<tr>
<td>Less-labor-bridge-for #2</td>
<td>$3656.76</td>
<td>$3603.53</td>
<td>$48.23</td>
<td>$3603.53</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$431.72</td>
</tr>
</tbody>
</table>
Tables of Comparative Costs

Often as an engineer you will find it necessary to determine the most economical and practical way to carry a railroad over a ravine. Two important factors should be given close consideration. Firstly, the cost of construction of a trestle as compared to that of an embankment. And secondly, the length of life the road is to be used as compared to the duration of the life of the trestle. Many times it may be found that the initial cost of a trestle would be much less than that of an embankment, but if the trestle must be replaced before they are through using the road, the cost of trestle may be greater than that of an embankment.

The following tables are of use in determining the comparative costs of trestles and embankments. Also the comparative costs of the pile and frame trestles.
SHOWING RELATIVE COSTS OF EMBANKMENT AND TRESTLE IN 100 FOOT SECTIONS, INCLUDING RAILS, TIES, AND BALLAST ON FORMER, AND RAILS, GUARD-RAILS, AND TIES ON LATTER

<table>
<thead>
<tr>
<th>HEIGHT FROM SURFACE OF GROUND TO GRADE IN FEET</th>
<th>EMBANKMENT PER. CU. YD. IN CENTS. RD.BD. -14' SLOPE 1½ - 1</th>
<th>TRESTLE TIMBER ERECTED (INCLUDING IRON) per M, B.M. PILE TRESTLE - piling 35° per lin. ft. in place: average penetration 10'</th>
<th>FRAMED</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>$64 $72 $80 $88</td>
<td>$376 $407 $439</td>
<td>$883</td>
</tr>
<tr>
<td>10</td>
<td>113 121 141 165</td>
<td>441 476 512</td>
<td>385</td>
</tr>
<tr>
<td>15</td>
<td>326 366 406 447</td>
<td>508 544 580</td>
<td>541</td>
</tr>
<tr>
<td>20</td>
<td>521 587 652 718</td>
<td>576 613 661</td>
<td>541</td>
</tr>
<tr>
<td>25</td>
<td>764 859 955 1050</td>
<td>748 805 868</td>
<td>796</td>
</tr>
<tr>
<td>30</td>
<td>1049 1180 1312 1443</td>
<td>816 872 928</td>
<td>872</td>
</tr>
<tr>
<td>35</td>
<td>1380 1552 1726 1897</td>
<td>990 1065 1140</td>
<td>1058</td>
</tr>
<tr>
<td>40</td>
<td>1754 1974 2193 2412</td>
<td>1057 1132 1218</td>
<td>1133</td>
</tr>
<tr>
<td>45</td>
<td>2174 2446 2717 2989</td>
<td>1202 1404 1606</td>
<td>1202</td>
</tr>
</tbody>
</table>
COST OF PILE AND FRAME TRESTLE COMPLETE, INCLUDING
FLOOR SYSTEMS, FOR DIFFERENT HEIGHTS, IN SECTIONS
OF 100 FEET

<table>
<thead>
<tr>
<th>HEIGHT</th>
<th>PILE</th>
<th>FRAME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$30</td>
<td>$35</td>
</tr>
<tr>
<td>5</td>
<td>546</td>
<td>606</td>
</tr>
<tr>
<td>10</td>
<td>611</td>
<td>674</td>
</tr>
<tr>
<td>15</td>
<td>678</td>
<td>742</td>
</tr>
<tr>
<td>20</td>
<td>746</td>
<td>811</td>
</tr>
<tr>
<td>25</td>
<td>918</td>
<td>1001</td>
</tr>
<tr>
<td>30</td>
<td>986</td>
<td>1070</td>
</tr>
<tr>
<td>35</td>
<td>1160</td>
<td>1263</td>
</tr>
<tr>
<td>40</td>
<td>1227</td>
<td>1332</td>
</tr>
<tr>
<td>45</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>