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Logging Railroad Construction

by

Stephen Waite

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Introduction

The purpose of this thesis will be to give the major steps in locating and constructing a logging railroad. I will also try to show the importance of accurate work in railroad location.

In this thesis I will follow the same steps that would be followed in the actual process of locating and construction a railroad.

Most of my data has been obtained from my own experience while working for the C. D. Johnston Lumber Corp. at Toledo and what I have learned in Logging Engineering courses at Oregon State College.

Logging railroads are being used extensively for a major transportation system by the larger logging companies. The skill with which a railroad is laid out will often determine whether a company will lose or make money. A few mistakes will often cause a large loss.

In the Transactions of American Civil Engineers, 1928 Walter J. Ryan said that the first logging railroads were built without technical skill. It was the duty of the logging superintendent to locate the railroad and he had little opportunity to plan ahead. These lines were extended from year to year until the country was logged off or obstacles were encountered. Locating engineers had to be called to solve the difficulties which were encountered. In 1928 there were more than 6,000 miles of logging rail-

roads in operation, and they were increasing about five percent per year. About twentyfive percent was replaced as spurs each year. This would be 2,000 miles of new road.

Reconnoissance

Before a tract of timber is logged, it is first necessary to determine whether there is timber with enough value on the area to make it proffitable to log. An estimate of the timber on the area is made by cruisers. A rough map is usually made at the same time.

The next step is the reconnoissance survey. This is a hasty examination of a belt of country to determine the best route of the possible routes. It's purpose is to determine the important features which make one or two routes better than the others. If there are two routes which appear to be nearly equal, a more detailed survey of each route is made. Although the reconnoissance is a hasty and rough survey, all routes should be considered. The most obvious route isn't always the best route. If there is a map of the area, it should be studied to find all of the possible routes.

There are often several saddles in a ridge that may be used if the road is crossing the ridge. The location and elevation of these saddles should be obtained in order that the ruling grade and alinement for each route can be determined. The best route would be a straight line between the controlling points, but this usually isn't possible

except in level country. The route selected must keep within the limits of grade, curvature, and type of construction.

In reconnoissance for logging railroads it is also necessary to consider the timber along the different routes. One route might open up more timber for logging than another route. After all of the factors are considered the route is selected and the grade between the controlling points is determined.

Preliminary Survey

The preliminary survey is a topographic survey of the belt of country through which the engineer estimates the line will pass. There are several methods which may be used. The most accurate survey is made with the transit and chain. The backbone line may also be ran in with a compass. This method is less accurate but has an advantage in its simplicity. The errors are local and not cumulative. It is possible to set a compass up on the opposite side of a tree which is on line but when a transit is used the tree would have to be cut down or an offset made.

Stations are set along the route at fifty or hundred foot intervals and in draws, ridges, and changes in slope. Levels are ran over the line to determine the elevations at each stake.

Cross-sections are taken at each stake to obtain the location of the contours. A five foot contour interval is usually used A handlevel, level rod, and a tape are usually used to locate the contours. The rodman first

holds the rod at the stake and one man uses the handlevel to place his eye at the height of a contour. The rodman then moves and places the rod on the next contour. The distance from the stake to this contour is measured and the contour and distance recorded in the notes. This is done on both sides of the stake until the contours on a large enough area are obtained. It is better to take a few more contours than needed. If this policy is used, it will probably save a trip back to the area for a few more contours.

It is possible for two men to take the cross-sections if the handlevel has stadia hairs. The levelman can read both the elevation and the distance. The distance can only be taken to the nearest foot by this method, but I think that this should be accurate enough if the distance wasn't too far from the main line.

The stadia method can be used for making the preliminary survey in open country. Shots are taken at changes in slope along the line. Both foresights and backsights should be taken on the backbone line.

As was stated before the transit method is the most accurate. I think that this method is the best to use in locating railroads. Usually a little money spent on the survey will save a larger amount of money on the construction of the railroad.

Location Survey

The data obtained from the preliminary survey is plotted to scale. One inch equals two hundred feet or one inch equals one hundred feet are often used. The data obtained from the cross-sections is located on the map and the contours drawn in. The contours and the preliminary line should be inked as it is usually necessary to make numerous trials in making the paper location.

A grade contour line is located on the map. The rate of grade which has been determined between the controlling points and the contour interval are used to find the distance between contours. The contour interval is divided by the rate of grade to find the distance between contours on the grade contour line. Dividers are set at this distance and the points marked on the map. The line shouldn't follow around each draw as this would make the line too long. A trestle or embanement would probably be put across the draw in the final location.

The next step is that of locating the line. It isn't possible to make the line run through each point with the practicable curves and tangents, but the line should run as close to these points as possible to keep the cuts and fills at a minimum. If the grade contour line has many bends in it, the curves should be located first. The tangents should be put in first if parts of the line has parts which are nearly straight. It will be necessary to

make numerous trials to determine the final location.

There are numerous factors to consider in plotting the paper location. The cuts and fills should be nearly equal. The moving of earth forms a very large part of the cost of building a railroad. If the cuts were larger than needed to make the fills the cost would be increased. It would also increase the cost if earth had to be borrowed to make the fills. There should be enough distance between curves in opposite directions. This distance is usually determined by the type of road. A main-line should have a greater distance than a spur.

The curvature should be within the limits of the maximum curve which has been set for the road, The type of road also determines the maximum curve. Where speed is desired the curves should be as easy as possible. It is preferable to make one simple curve or a compound curve rather rather than two simple curves which bend in the same direction with a very short tangent between. Reverse curves with no connecting tangent should never be used except on switch work and where the speed will be very slow.

There are several factors which determine the maximum grade. An easier grade would be used on a main-line which will be used for a long time than on a spur which will only be used for a short time. The type of locomotive should also be considered in determining the grade.

An easier grade should be used when the grade is against the haul. A larger rate of grade can be used when the grade is favorable to the haul. This is one factor that should be considered in constructing logging railroads, and usually isn't necessary to consider on other railroads. The other railroads usually haul about as much both ways, but the logs are always taken out in one direction on the logging railroads.

Sharp curves should be compensated on main lines. Curves increase the resistance which the locomotives have to overcome and to equalize the resistance on curves the rate of grade should be reduced. The resistance on curves varies with the speed. The speed of the trains should be estimated to find the amount of compensation. The amount of compensation usually used under average conditions is from 0.04 to 0.05 per degree of curve.

Trestles and fills should also be considered in making the paper location. Sometimes it would be cheaper to make a smaller cut and put in a trestle instead of a fill. The relative costs between fills and trestles should be considered. These costs would have to be found for each operation as the costs would vary under different conditions. The cost of moving dirt wouldn't be the same. The cost of material for building the trestle would probably be different. It might be hard to get material for the trestle.

It might be better to put in fills even where the trestle would be cheaper if there is danger of fire. Fire very often destroys trestles where the ties wouldn't be destroyed on a fill. The life of the road should also be considered in determining whether to use a trestle or a fill. In some cases a trestle would be cheaper than a fill but one trestle wouldn't last the life of the operation. In this case it would be necessary to find the cost of the number of trestles needed for the time that the road would be used.

Switchbacks are used in some cases. They shouldn't be used unless necessary as it is necessary to stop and change directions on the switchback. This reduces the speed with which a train of logs can be brought out.

There are large differences in elevations in the country where a lot of logging is being done. In order drop down without the cost of building a long line of road inclines are often used. The cars are let down and brought up the inclines with donkeys. Counterbalanced inclines are sometimes used. They have a double track and one car can be taken up as another is let down the incline. The amount of timber to be taken out over the incline and the number of cars per day would probably determine whether one or two tracks would be constructed.

The engineer taking into consideration all of these factors including the proper balancing of cuts and fills locates the line on the map. He makes a profile of the line at the same time. The line on the map and the profile are studied and new lines ran in to determine the best possible location for the road.

After the line has been located on the map notes are prepared for the alinement. There are several methods of obtaining the alinement. The intersection angles of the tangents can be measured with a protracter, and the distance scaled. I think the best method is to scale the coordinates of the points of intersection of the tangents and compute the distances and angles. The degree of the curves were known when the line was plotted.

If tapered curves are used, they are computed and recorded in the notes. Tapered curves are used to allow for the gradual increase of the superelevation on the curves.

A transit and chain is used to run in the final location in the field. Nothing but precise work should be allowed. Stakes are set at fifty foot intervals and at the beginning and end of the curves. The line should be checked frequently by ties to the preliminary line. The transit stations should be witnessed with points off the road so the points may be located later after clearing.

Levels are ran over the line and elevations taken at each stake. The elevations should be taken at the top of ridges and the lowest point in the draws as wellas the regular stations.

A profile is made of the final location line. The level notes are used to make the profile. The grade line is placed on the profile. The grade line may be changed if the cuts and fills don't balance as they should. After the grade line has beenput on the profile the elevation of the grade line at each station is computed. The cut or fill at each station is the difference between the ground line and the grade line. Vertical curves should be computed at changes in grade before the cuts and fills are found. After the cuts and fills are determined slope stakes are set at each station. The slope used depends on the type of material in the cut and whether itis a cut or fill. A steeper slope is used in rock than is used in earth or sand. The slopes in cuts are steeper than the ones in fills. A handlevel, tape and level rod are used to set the slope stakes.

The volume of the earth work is computed from the notes taken when the slope stakes are set. If the cuts are larger than the fills,it isn't necessary to compute the volume of the fills, but if the cuts and fills are nearly equal or the fills larger than the cuts, the fills

should be computed. This is necessary to determine the amount of earth that will have to be borrowed.

To find the volume of the earth the end areas are computed at each station and the average end areas between stations is multiplied by the distance between the two stations. The volume is then changed to cubic yards. I think that the average end area method is usually accurate enough if the prismoidal correction is used where there is very much difference in center heights between the two stations.

If the work is to be contracted, the cost of constructing the road can be estimated by finding the amount of earth to be moved, the cost of bridges, the number and length of culverts, and the number of stumps in the right of way. The cost of falling and bucking is usually charged to logging. If a company does the construction of the road, it isn't necessary to estimate the cost and compute the volume of earth work. Some companies find this data because they desire to keep a record of the cost of the railroad.

If the work is contracted the amount and distance of overhaul should be found. The overhaul earth is that which has to be moved a distance greater than the free haul distance. The difference between the distance that the earth has to be hauled and the free haul distance is the

overhaul distance. A graph is used to find the center of mass of the cut and fill. The distance between the centers of mass is the average distance. The free haul distance is subtracted from the average distance to find the average overhaul distance.

Construction

After the line has been located on the ground the clearing of the righ-of-way is started. A wide strip of trees is cut down along the line. The trees are bucked up into the right log lengths. A spar tree is rigged and the trees are taken off the right-of-way. The logs are cold-decked around the spar tree and left until they can be put on the cars after the road is completed.

The powder monkey and his helper follow the cold-decking crew. It is his duty to blow out the stumps which are on the right-of-way. He relies on his experience as to the amount of powder to use. His policy is usually to use plenty of powder. This reduces the risk of having to blow the stump again. Sometimes the stumps are only loosenedand the cat or shovel finish pulling them out. This reduces the cost of powder but increases the cost for the cat or shovel.

Tractors or shovels are used in grading. The tractor and "bulldozer" are being used more now than in the past. They are usually cheaper than shovels but companies which have expensive shovels cannot affort to discard them and

buy new equipment. Emanuel Fritz in Tractor Advantages in the Redwood Regon states that the bulldozer tractor has given cost figures as low as seven cents per cubic yard against seventeen cents for the steam shovel and dump car method.

Culverts should be put in draws and places where there will be water running across the road. The size of culvert depends on the amount of water that will go through the culvert at the maximum stage. This may be found by a previous high water line or by estimating the amount of land drained.

The ties and rails are placed after the grade has been leveled off. The better ties are used on the main line where they will be used for a longer time. A poorer grade of tie is usually used on the spurs where the life of the tie will be longer than the length of time that the spur will be used.

The rails used at the C. D. Johnston Lumber Corp. were from sixty to seventy pound rails. The heavier rails were found to be better than the lighter ones. The cost of maintenance was reduced where the heavier rails were used. The rails that a company has on hand and the weight of the loads to be taken over the road determine the weight of the rails. It would be too expensive to buy heavier rails if the company owned lighter rails.

The ties and rails are brought to the end of the track on flat cars. Most companies use a track laying machine which takes the ties and rails from the car and places them on the road bed. This machine increases the speed of track laying and reduces the work. The men have to place the ties and fasten the rails to the ties.

Ballast is put between the ties after the ties and rails are in place. The ballast is used to keep the rails up to the grade line, hold the ties in place, carry off the rain water, and give elasticity to the road bed. The ballast is very esential to keeping the rails up to the grade line and to carry off the water. If there isn't enough ballast, the water will remain under the ties and form a soft place in the road bed. The ties will sink into the mud when a heavy load passes over the track.

The cost of ballast varies depending on the material available, the distance of haul, and other factors. If the road is to be used for a long time, plenty of ballast should be used.

Summary

I have tried to give most of the main steps which would be followed in the location and construction of a logging railroad. It was impossible to go into much detail because of the scope of my topic, although this should give one a general idea of the necessary steps in railroad location.