TWO SYSTEMS OF
LOGGING ROAD LOCATION
USED IN WESTERN OREGON

SUBMITTED BY
HOWARD HOPKINS

DECEMBER 10, 1954
SUMMARY

In the two methods of road location covered, the preliminary survey is the same. The main difference between the systems is in the method of locating and staking the curves.

In the first system, the middle ordinate method, there are no instruments used in staking the curve. They do not recognize any particular definition of curve, and there is no allowance made for the difference between the distance in stationing and the distance on the fifty foot chords in which they measure around the curve. However, the method has proved acceptable for their standards. It is relatively inexpensive, for there is only one trip over the line required to complete the location proper.

The P. I. method is a little more refined than the middle ordinate because it is possible to better fit the curves to the ground. The arc curve definition is used, and the chord distances are corrected for the distance on the arc. The P. I. method involves more time in the location, but the extra time is felt in better alignment and less heavy construction on the curves.

The slope stakes are set from tables. The only difference between the systems is that one company made their own slope stake tables and the other uses a set that is commercially available.
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TWO SYSTEMS OF LOGGING ROAD LOCATION USED IN WESTERN OREGON

INTRODUCTION

A road location survey consists of a connected series of steps or procedures. Without any one step the whole survey suffers either in accuracy or in efficiency. However, the standard method set up for locating long term, expensive roads are too expensive and detailed where the road is to be used, at the most, only a few years before it is abandoned or at least no longer maintained.

A secondary logging road in Western Oregon is an example of the kind of road that is intensively used for several years and then abandoned. The traffic is heavy and runs as fast as possible when it is in use, but the road value depreciates quickly, for once the allowable cut of timber has been taken, it is usually necessary to wait many years before the road is again used for log hauling. It is not usually necessary to keep the road in anything but a semi-passible condition between cuttings; therefore, for all practical purposes, the road will be abandoned after each rotation.

It is this secondary logging road location in Western Oregon that I will discuss in this paper.

There are, no doubt, as many ways to locate logging roads as there are men that locate them, for each engineer
has tricks and short cuts that he uses and advocates. This paper will deal with two methods of location that are now being used in Western Oregon by two large timber-owning corporations.

THE PRELIMINARY RECONNAISSANCE

The preliminary reconnaissance is the process by which the engineer, while still in the office, attempts to pick the most favorable routes from the starting point of the road to the destination from a contour map. On each route tentatively chosen, he will note obstacles that will have the effect of controlling the grade between the start and the finish. Then by calculating the difference in elevation and the horizontal distance of the projected road, he can estimate the grade necessary along any portion of the road. This is not the final grade to be used, but merely a guide to be checked on the ground.

The controlling factor in the preliminary reconnaissance is the accuracy of the topographic map that is available to the engineer. Maps from aerial photographs will suffice if there was sufficient care taken with them. However, if accurate maps on the ground are available, the ground map is usually far superior in forested areas.

THE RECONNAISSANCE

The reconnaissance is designed to take the engineer
over the ground that the road will follow. This gives him an opportunity to look over the ground and to see what will confront him on the location survey.

The common method of road reconnaissance is to use the abney to maintain a grade and the pace to keep track of the distance. The party chief runs the abney, and he is aided by one man with an axe, a flashlight, and a supply of stiff colored cards. They start from an existing road or some point that can be tied into a road. They may either run the abney along the actual line of grade or at the abney-man's H. I. above the grade. After the grade level for the abney is established, the helper goes out as far ahead as the man with the abney can see the flashlight beam. The helper waves the flashlight horizontally and moves it up or down until it is on grade from the abney ahead. He then drives his axe into a nearby tree and sets a card in the axe mark at the height that he was holding the flashlight. This point is then on the grade line; therefore the abney-man can move up to the card and take another sight on his helper who in the meantime has moved ahead. This procedure is continued as they move along the grade line.

As the grade line is extended, the engineer should look for many things along the route. Where it is necessary he notes how much the grade line would have to be moved to place the center line on more favorable ground.
When he finds an obstacle that is on the grade line, he should note the distance he has come and the difference in elevation to a better site.

He should watch for easy creek crossings. Where he can cross the creeks at places of very little creek slope, it will save a lot of fill on the lower side and quite a bit of culvert. When possible he should find a creek bottom wide enough to make a turn without cutting too heavily into the side slopes of the creek valley.

Saddles can be an aid to construction if it is possible to get from heavy construction on one side of the hill to more favorable ground on the other side. They should always be kept in mind as a possible way to get a spur out to a landing on the other side of the ridge.

Because of the steepness of the side slopes that are normally encountered in this region, it is sometimes very difficult to find a good place to put a curve or a switchback. The engineer should look for places of this nature especially if the estimated grade is in excess of that normally used on the operation. The ideal situation for a switchback would be a relatively level area at least twice the radius of the minimum degree of curve, but in cases concessions have been made by shortening the radius to keep from cutting too heavily into the sidehill. At any rate, the curve of the shortest radius will probably be the controlling factor of truck speed on any section.
of road so it would be well worth the engineer's time to scout out the best possible place for the difficult curve.

A road should be as straight as possible from the edge of the cut area to the landing, and where a choice is afforded it will aid the logger quite a bit if the road is not too crooked inside the unit especially on a highlead side.

A large part of the reconnaissance is to scout out ways to get by obstacles. If the grade should strike through extra expensive road construction, like solid rock or very steep side slopes, the engineer should note the distance he has come along the grade line and the difference in elevation to better construction so a change of grade can be made, or he should look for a round-about way of bypassing the obstacle.

Road rock is a problem to all-weather loggers. It behooves the engineer to note all of the possible rock pits along the grade and to keep them in mind while he is figuring the probable costs of alternative roads.

Upon arriving at the termination point or at one of the control points, it may be that the grade line ends above or below the desired point. If such is the case, it is possible to correct the line to get a uniform grade all the way back or to change the line as necessary to make best possible use of construction advantages. It is a simple problem to adjust the line because the pacing
yields the approximate horizontal distance traveled, and the vertical distance can be obtained by stepping up the line with the abney set on level. The vertical distance is divided by the horizontal and the quotient of that is multiplied by one hundred to get the amount of correction to apply to the grade that was run on the ground. This is done for all the places where the grade line should be changed.

ROAD LOCATION

Up to this point of the survey the two methods coincide in their applications. The difference comes in the method of running the final survey which includes staking out the curves.

Neither method depends on planning the curves on paper prior to laying it out in the field. No work is done in the office after the preliminary study of the map before the reconnaissance, and all of the calculations and work is done in the field.

MIDDLE ORDINATE METHOD

This is primarily an "eye-ball" system, for it utilizes no instruments in the location work.

It requires a two to four man crew with a three man crew probably the most efficient depending on the amount
of brush to cut and on whether stakes are cut from brush or finished stakes are carried along. In a three man crew the party chief is the location engineer, the number two man is ahead as the head-chainman, and the other man is an axeman to help with clearing and to cut stakes if necessary.

The equipment needed is a tape, an abney, and a stick 5.5 feet long. The tape is ordinarily 100 or 200 feet long and the abney graduated in percent of slope. The stick is graduated in half foot intervals and carried by the engineer.

The tangents are located by following along the grade line where it runs in a straight line. The tangent is set by the head-chainman going ahead fifty feet and lining up with the stake behind, where the engineer is waiting, and the stake behind that. When he is out fifty feet and lined up with the two stakes behind, he sets that stake then both he and the engineer advance another fifty feet and set the next stake the same way.

When the location comes to a place where the line of tags on grade turn, it is necessary to cut in a curve. This is where the 5.5 foot stick is used. The engineer determines the approximate middle ordinate it will take for one hundred feet of stationing to make the curve. This estimate comes from previous experience and his own judgement. When the middle ordinate is decided upon, the head-chainman moves out near the first fifty foot station
on the curve. The engineer stays at the F. C., commonly an even fifty foot station, and with his 5.5 stick he measures in toward the center of the curve one-half of the middle ordinate, and he stands the stick up at that point. The head-chainman moves until he is sighting directly over the 5.5 stick back to the station behind the engineer, the station behind the P. C. When the head-chainman is lined in and out fifty feet from the engineer, he sets a stake. The engineer moves up to the stake just set and measures in toward the center of the curve the full middle ordinate distance. He stands or holds his stick up at this point so that the head-chainman, who in the mean time has gone out another fifty feet, can line in with the 5.5 stick and the P. C. When the head-chainman is lined in and out fifty feet beyond the station the engineer is occupying he sets that stake. This is continued until the engineer comes to the P. T. At the P. T. the engineer measures only one-half of the middle ordinate distance, and the head-chainman sets the next stake from lining up with the 5.5 stick and the station behind the P. T. Now, the station ahead of the P. T. and the P. T. are on tangent.

Many times this curve is hard to fit to the ground because, to keep it simple, it must begin and end at an even fifty foot station. Through the extensive use of the compound curves it is possible to use this as a fast,
easily taught method of location.

In noting the location in the field book, the middle ordinate is put in the book. It is plotted from a compass traverse taken after the location is completed.

THE PROFILE

The profile is compiled by use of trigonometric leveling. The leveling is done as the center line progresses.

The equipment used is the 5.5 foot stick and a percent abney. The abney is used from the top of the 5.5 stick from which it is sighted at a point 5.5 feet high on the head-chainman. Sometimes a flashlight is held by the head-chainman at 5.5 feet to make the abney shot easier.

The location is run by fifty foot stations. Each time the head-chainman sets a stake he stands up straight at the stake, and the engineer takes a reading on him with the abney. The engineer then notes the abney reading and converts it to the difference in elevation and to the elevation of the ground at that point. The predetermined grade of the centerline is converted to elevation at each station; therefore knowing the elevation of the grade and the elevation of the ground, the cuts and fills can be computed.

This is carried on from station to station, and an effort is made to have the cuts at centerline balance
the fills. They can usually be balanced by changing the grade or moving the centerline.

The profile is made after the road has been located and all of the cuts and fills determined. It serves primarily as a check on the balance between the cuts and the fills at centerline.

THE P. I. METHOD

This method is somewhat more refined than the middle ordinate method. It involves the actual calculation of the curve components, and it does not require as many compound curves because the curve can start from an uneven station.

The equipment used is a staff compass, tape, and a copy of Calder's Forest Road Engineering Tables. It would be just as well to use a more refined set of tables, but since angles are taken by staff compass it is deemed unnecessary.

The work of location is started by brushing out tangents as determined by the grade line. A P. I. stake is set at the approximate convergence of two tangents. The engineer leaves the compassman at the P. I. behind; then he goes forward along the grade line to the point where the next tentative P. I. will be. From the P. I. ahead he will direct the compassman to make the final setting of the P. I. behind. Then the two men will brush toward
each other until the tangents and semi-tangents are clear. The compassman will again wait at the tentative P. I. while the engineer goes out along the grade line to where he thinks the next P. I. will be. This process is repeated until sufficient tangents have been cleared and P. I.'s set to furnish a whole day of curve calculation and staking. To locate the curves, the tangent and semi-tangent are staked to the P. I., for the line of stakes along the semi-tangent are used to stake the curve by tangent offsets. The compass is used to measure the I angle. The degree of curve is arrived at by estimating the external or the middle ordinate of the desired curve. The calculations are done in the field.

The curves are normally staked by using tangent offsets with the "x" distance measured around the curve and the "y" or offset distance measured perpendicularly from the semi-tangent. However, the compass can be used to stake the curves by deflection angles or bearings on the chords if care is taken to watch for local attraction when the compass is moved.

This method is more refined and somewhat slower than the middle ordinate method; however, the greater expense tends to give better road alignment with truer curves than the "eye ball" procedures. Since it is difficult to evaluate the effect that true curves have on hauling time it is hard to judge between the two methods from
that base.

This type of location works well with just two men in the crew. More are necessary only in heavy brush.

PROFILE

The grades are roughed-in by the reconnaissance grade line, but to arrive at the final grade this procedure employs differential leveling.

Here again a two man crew is sufficient. Equipment is a hand level, leveling rod marked in tenths, and profile paper.

One man acts as leveler while the other operates the rod. Because it is difficult to see over fifty feet, the rodman turns on nearly every even station.

After the leveling is completed for a given section, the ground profile is plotted on the profile paper. The grade profile is roughed-in and adjusted until the cuts on the center line approximately balance the fills. This system of balancing the cuts and fills usually gets too much dirt so that frequent turnouts are produced even where no actual provision for them was made in the engineering.

It sometimes happens that the grade cannot be adjusted enough to the ground. When that happens it is necessary to go back and revise the section where this occurs; therefore it is not too wise to get the location too far
ahead of the profile.

After the profile is completed, the cuts and fills are written on the centerline stakes in the evening on the way home.

**SLOPE STAKES**

The two methods again coincide in the placing of slope stakes, for both methods advocate the use of slope stake tables. One group uses tables that they compiled while the other company uses *Calders Forest Road Engineering Tables*.

The company that made their own tables calculated theirs for one-tenth foot difference in cut on centerline and on every percent slope; while Calder calculated for only every five-tenths foot difference in cut on centerline and every even percent of slope.

The equipment used were tables, abney, and fifty foot cloth tape.

The procedure is for the engineer to make an approximate right angle to the centerline by pointing one arm at the stake ahead and one arm at the stake behind. He then closes his eyes and brings his arms together in front of himself. He opens his eyes immediately and where his hands are pointed, is an approximate right angle to the centerline. He takes an abney shot up along the hill to get the approximate percent of slope. Then he consults
the tables for the distance along the slope to the top of the cut for the given cut on centerline and percent of slope of the ground. The helper goes out the given distance on the slope and the engineer takes a shot on him to get the true slope. If the slope is different than that estimated at first, the engineer again consults the tables to find the new distance on the new slope. The helper goes there and sets the slope stake.

REFERENCE POINTS

Both outfits agree in principle on the way to reference the location. A tree, preferably below the road, is blazed with the face aimed right at the stake. The distance to the station, the grade difference up or down to the grade at the station, and the stationing is given under both systems. In one system the bearing from the tree to the station is also given.

With this information given at intervals of about 150 feet it is possible to relocate the centerline if it becomes necessary.