DIVISION 150
Engineering

Section 160—Quality Control & Quantity Measurement

Description

160.01 Work. Provide quality control in conformance with the Inspection of Construction provisions of this contract to ensure compliance with the drawings, specifications, and provisions of the contract. Measure the quantities of completed work in conformance with the provisions of the applicable specification. Provide all personnel, equipment, tests, and reports necessary to meet the requirements of this specification.

Construction

160.02 Quality Control & Quantity Measurement System. Provide and maintain a quality control system that will ensure that all services, supplies, and construction required under this contract conform to the contract requirements. Perform, or cause to be performed, the sampling, inspection, and testing required to substantiate that all supplies, services, and construction conform to the contract requirements.

In addition, perform, or cause to be performed, all measurement of quantities of materials incorporated into the work or work processes that are to be measured under the provisions of the contract.

(a) Quality Control Plan. Submit in writing the following:

(1) Authorities and responsibilities of inspection and testing personnel.

(2) Experience and qualifications of inspection and testing personnel to be assigned and name and location of any (for hire) testing facility to be used.

(b) Approval of Quality Control Plan. Before beginning work, submit proposed quality control plan for all items requiring quality control to the CO for review. Within 5 days of receipt of the plan, the CO will determine whether the plan adequately covers quality control requirements. Do not perform construction work before receiving written approval of the proposed plan. Submit to the CO in writing any proposed changes in the approved quality control plan. Do not put proposed changes into effect until approved in writing by the CO.

160.03 Sampling, Testing, Inspection, & Measurement of Quantities. Provide and maintain appropriate measuring and testing devices, equipment, and supplies to accomplish the required measurement, testing, and inspection in a timely manner. Make all tests, measurements, and certifications as required by the

drawings and specifications. Take samples and perform inspections and tests as necessary to achieve the quality of construction required by the contract, and make required measurements of work performed onsite or offsite under this contract. Sampling and testing frequency for specific items will be SHOWN ON THE DRAWINGS, in the Standard Specifications, or in a SPECIAL PROJECT SPECIFICATION.

Where random sample or random measurement is specified, provide a stratified statistically random sample. Determine random numbers in accordance with ASTM D 3665, sections 5.1 through 5.7, or use a computer-generated random number program approved by the CO. Ensure that the sampling is stratified to eliminate the possibility that sample points are "clustered." Perform stratification by dividing the total quantity for the applicable bid item by the sample frequency. This process divides the total project quantity of one lot into sublots. Use the random number to obtain a random sampling point within each sublot. A lot may be terminated and a new lot started when approved by the CO. After a lot is terminated, do not combine it with any other lot. If material within a sublot fails to meet specification requirement, the CO may allow the sublot materials to be reworked and resampling to be performed at new randomly selected locations.

The CO may reject any quantity of material that appears to be defective based on visual inspection or test results. Do not use such rejected material in the work. Results of tests run on this rejected material will not be included in results of lot acceptance tests.

160.04 Records of Inspection, Tests, & Measurement. Meet the following requirements for inspection and tests, and as-built drawings:

(a) Inspection and Tests. Maintain current records of all inspections and tests performed. The following format, or one with the following information, will be acceptable to the Government:

Road No. _____ Contract No. _____

Pay Item No.	Test	Date	Station	Standard	Results	Test By (Initials)

Certify in writing that all inspections and tests were performed in accordance with specifications.

(b) As-Built Drawings. Maintain a set of the contract drawings depicting as-built conditions. Maintain these drawings in current condition, and make them available for review. Indicate all variations from contract drawings in red on the drawings. Upon completion of the contract work, submit as-built drawings to the CO.

160.05 Certifications & Measurements. Meet the following requirements for offsite-produced materials and quantity measurements:

(a) Offsite-Produced Materials. Furnish certificates executed by the manufacturer, supplier, or vendor, stipulating that all materials produced offsite that are incorporated into the work meet the applicable requirements SHOWN ON THE DRAWINGS or stated in the specifications. Certify all incidental purchases needed to remedy minor shortages of material.

(b) Quantity Measurements. Make all measurements for computation of quantities for all work items, except those specified for payment by designed quantity or lump sum. Compute the quantities for periodic progress payments; the CO will compute the quantities for the final payment based on measurements taken. All Contractor measurements are subject to verification. Submit all field notes, calculation sheets, and other data used to determine quantities, and certify in writing as to the accuracy of the measurements and computations submitted.

The following format, or one containing the following information, will be acceptable to the Government:

Road No. _____ Contract No. _____

Pay Item No.	Date	Station	Quantity or Measurement	Measured By (Initials)

Measurement

160.06 Method. Do not make separate measurements for this section.

Payment

160.07 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS. Otherwise, quality control and quantity measurement will be incidental to other specified work.

Payment will be prorated based on the percentage of work accomplished on the related PAY ITEM that meets specifications.

Section 161—Certification for Quality & Quantity

Description

161.01 Work. Provide certification that the quality and quantity of construction conforms to the drawings, specifications, and requirements of the contract.

Construction

161.02 Certifications & Measurements. Meet the following requirements for offsite-produced materials and quantity measurements:

(a) Offsite-Produced Materials. Furnish certificates executed by the manufacturer, supplier, or vendor, stipulating that all materials produced offsite that are incorporated into the work meet the applicable requirements SHOWN ON THE DRAWINGS or stated in the specifications. Make each certificate apply to a single commodity or invoice. Certify all incidental purchases needed to remedy minor shortages of material.

(b) Quantity Measurements. Make all measurements for computation of quantities for all work items, except those specified for payment by designed quantity or lump sum. Compute the quantities for periodic progress payments; the CO will compute the quantities for the final payment based on measurements taken. All Contractor measurements are subject to verification. Submit all field notes, calculation sheets, and other data used to determine quantities, and certify in writing as to the accuracy of the measurements and computations submitted.

The following format, or one containing the following information, will be acceptable to the Government:

Road No. _____ Contract No. _____

Pay Item No.	Date	Station	Quantity or Measurement	Measured By (Initials)

161.03 Records. Meet the following requirements for as-built drawings:

As-Built Drawings. Maintain a set of the contract drawings depicting as-built conditions. Maintain these drawings in current condition, and make them available for review. Indicate all variations from contract drawings in red on the drawings. Upon completion of the contract work, submit as-built drawings to the CO.

Measurement

161.04 Method. Make no separate measurements for this item.

Payment

161.05 Basis. Payment will be considered incidental to other pay items in this contract.

Section 170—Construction Staking, L-Line

Description

170.01 Work. Complete the construction staking of a road by the L-line method in accordance with the drawings and specifications. Furnish all labor, equipment, instruments, materials, transportation, and other incidentals necessary to complete the construction staking in accordance with these specifications and acceptable engineering practice. In addition, set grade-finishing stakes, and stake major structures.

Conduct construction staking under the direction of a licensed professional engineer or land surveyor who is closely associated and familiar with the construction staking. Periodic visits to the project site are required.

Materials

170.02 Stakes. Provide stakes that all have the nominal dimensions SHOWN ON THE DRAWINGS or stated in the SPECIAL PROJECT SPECIFICATIONS. Ensure that identification stakes and hubs are of sufficient length to provide a solid set in the ground and space for marking above ground when applicable. Other dimensions and materials may be used, such as steel reinforcing bars, wire flagging and markers, and metal pins, if approved in writing by the CO. Paint the top 50 mm of all slope, guard, reference, clearing, and structure stakes, or mark them with plastic flagging. Use colors on stakes or for flagging as SHOWN ON THE DRAWINGS or stated in the SPECIAL PROJECT SPECIFICATIONS.

170.03 Survey Notes. Furnish field notebooks or note papers. Use moisture-resistant paper for survey notes. Keep notes in books with covers that will protect the contents and retain the pages in numerical sequence during field use. When using electronic data collectors, provide electronic and hardcopy notes as listed in the SPECIAL PROJECT SPECIFICATIONS.

170.04 Government-Furnished Documents. Drawings, P-line survey notes, P-line to L-line offset data, construction staking notes, and the projected locations of catch points will be furnished by the Government. Return one set of "as-staked" drawings and all documents to the CO.

Survey Requirements

170.05 Precision. Accuracy and precision requirements are contained in tables 170-1 and 170-2. Perform all work under this specification to meet the

Table 170-1.—Accuracy requirements for reestablishing P-line, traverse, and elevations.

Precision Class	Minimum Position Closure	Angular Accuracy (±)	L-Line Tangent Control Points[a] (±)	Vertical Closure[b] (±)
A (Bridges)	1/10,000	2 sets, direct/reverse 10” rejection limit	N/A	5 mm or 20 mm/km[c]
B	1/5,000	2 sets, direct/reverse 20” rejection limit	30 mm	50 mm or 200 mm/km[c]
C	1/1,000	1 set, direct/reverse 1’ rejection limit	60 mm	500 mm/km

a. Accuracy of offset measurement.
b. Determine vertical closures at intervals not to exceed 1 km, as measured along centerline.
c. Use greatest value.

precision requirements DESIGNATED IN THE SCHEDULE OF ITEMS or stated in the SPECIAL PROJECT SPECIFICATIONS.

170.06 Survey Notes Format. All notes will become the property of the Forest Service. Use the slope stake note format shown in figure 170-1. The sketch in the lower half of figure 170-1 is for information only, and is not required as part of actual slope stake note format. Other formats may be used if approved by the CO.

Print all manually recorded survey notes in characters at least 4 mm high, and make them legible at a distance of 750 mm. Delete errors by lining out. At the beginning of each day’s work, record date, crew names and positions, instrumentation, and weather in the notes. Ensure that the party chief signs or initials each page of the notes immediately after the last entry for each day’s work.

Consecutively number electronically recorded survey notes, and use headings to identify the contents. Support and accompany the notes with a bound Day Book that records the project name and, for each day, the date; crew names and positions; instrumentation; weather; type of survey; stationing of sections between which the survey was performed; and survey data or sketches that cannot be electronically recorded. Ensure that the party chief signs or initials the electronically recorded notes and Day Book immediately after the last entry for each day’s work.

Table 170-2.—Cross section and slope stake precision.

Item	Precision A (±)	Precision B (±)	Precision C (±)
Allowable deviation of cross-section line projection from a true perpendicular to tangents, a true bisector of angle points, or a true radius of curves	2°	3°	3°
Take cross-section topography measurements so that variations in ground from a straight line connecting the cross-section points will not exceed	150 mm	300 mm	600 mm
Horizontal and vertical accuracy for cross sections, in millimeters or percentage of horizontal distance measured from traverse line, whichever is greater	30 mm or 0.4%	45 mm or 0.6%	60 mm or 1.0%
Horizontal and vertical accuracy for slope stake, slope stake references, and clearing limits, in millimeters or percentage of horizontal distance measured from centerline or reference stake, whichever is greater:			
Slope reference stakes and slope stakes	30 mm or 0.4%	45 mm or 0.6%	60 mm or 1.0%
Clearing limits	300 mm	300 mm	300 mm

170.07 Reestablishing Preliminary Survey Line. A preliminary survey line has been established on the ground for this project, with initial and specific succeeding survey points referenced. Reestablish missing P-line points necessary to control subsequent construction staking operations to the precision DESIGNATED IN THE SCHEDULE OF ITEMS.

170.08 Establishing Centerline. Determine the direction of centerline (L-line) tangents using coordinates furnished by the CO. Locate at least two points on each tangent to establish its direction. Do not change the location of tangent lines established on the ground.

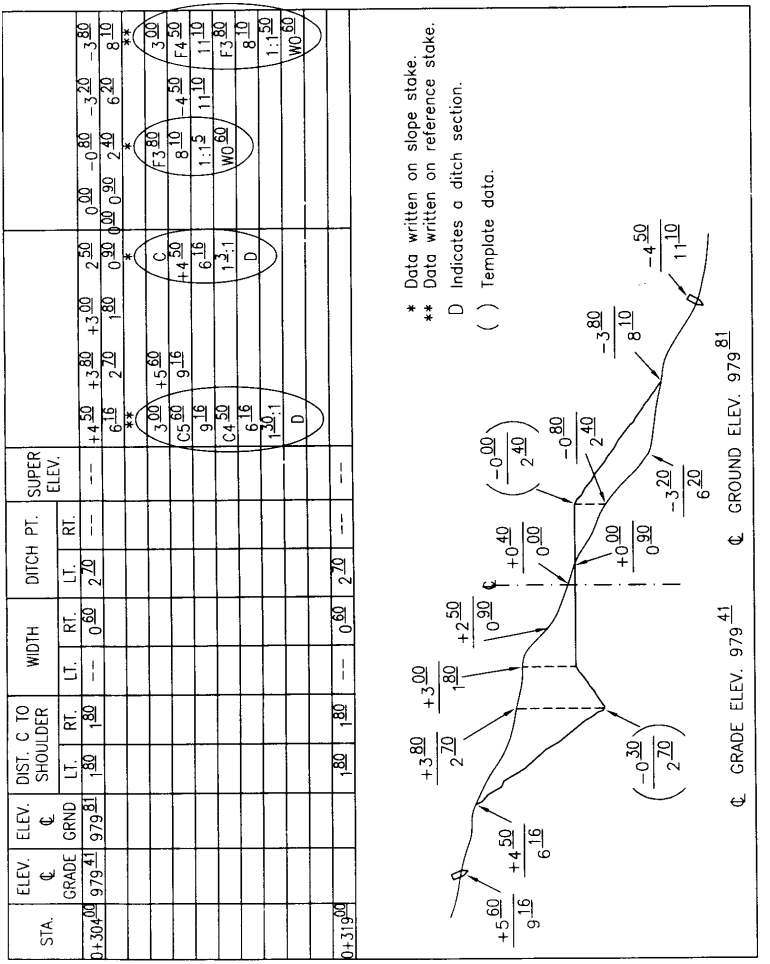

Figure 170-1.—Slope stake note entries related to actual ground elevations.

Measure the deflection angle from one tangent to another. When the measured deflection angle differs from the one SHOWN ON THE DRAWINGS, use the measured angle and the curve external (E) SHOWN ON THE DRAWINGS to compute new curve data. Compute the new curve data and note them in the field books, and on the "as-staked" drawings. Establish the new control points (P.I., or P.C.'s & P.T.'s) on the ground using hubs and tacks.

Throughout the project, continuously establish centerline points using horizontal distance measurements, and stake them to the nearest 3 mm for control points, and 30 mm for other points. Mark centerline stakes as shown in figure 170-2. Introduce equations at the P.T. of curves to adjust field stationing to that SHOWN ON THE DRAWINGS or in the staking notes when the difference between designed and located centerline stationing exceeds 1.5 m. Set centerline stakes at even 15-m intervals when practicable, at significant breaks in the ground, at culvert locations, at equation points, or at other locations indicated in the staking notes. Set stakes no more than 15 m apart. Stake all curves of 20 degrees or more every 10 m. Stake all other curves every 15 m.

Where centerline stations fall in an existing trail, obstruction, or roadway, offset the stakes left or right from centerline (perpendicular to tangents and on the radial lines of curves) clear of the trail, obstruction, or roadway, and mark the offset distance on the side facing the centerline. As centerline point, use a 20-penny or larger nail that is flagged and driven at least 25 mm below the road surface.

Clear the survey line to facilitate travel and surveying. Remove clearing slash from the travel or work area. Cut all brush and trees as near to the ground as possible.

170.09 Referencing Centerline. Reference centerline control points, and make them intervisible after clearing is completed to facilitate reestablishment of the centerline. Measure references to the precision of the centerline survey. Establish references consisting of two intersecting lines with an included angle of at least 30°. Place the forward reference a minimum of 8 m outside the clearing limits as computed from the preliminary slope stake printout notes, and place the rear hub or point on each line not less than 10 m beyond the forward hub or point. Mark reference points with hubs and tacks.

170.10 Vertical Control & "L" Profile Levels. Relocate bench marks that were established during the P-line survey that are within the clearing limits to points 6 m or more outside the clearing limits. Determine elevation of relocated bench marks by the precision class specified, as listed in table 170-1. Construct bench marks to be permanent and to allow a level rod to stand vertically and squarely on the mark. Bench marks may be established by driving a 40-penny or larger nail into a notch cut in the base of a tree, by marking a point on a stable rock, or by other approved means. Drive spikes into trees less than 300 mm above the ground. Record location and descriptions of relocated bench marks in

the level notes. Set at least two bench marks at each bridge and structural-plate culvert site.

Use appropriate survey equipment between bench marks to determine centerline ground elevations on L-line stations, to the nearest 30 mm, and to verify bench marks.

170.11 Discrepancies. Compare the staked centerline horizontal and vertical alignment with the design data. Refer to the CO any differences found between previously recorded and observed elevations of bench marks, and any differences exceeding 1 degree in angle found between the horizontal alignment data SHOWN ON THE DRAWINGS and the alignment observed on the ground. Report differences in centerline profile elevations exceeding 300 mm at any two or more consecutive points to the CO for evaluation and possible revision. Defer the staking of these areas until these differences are resolved by the CO.

170.12 "L" Topography Cross Sections. Take cross sections at right angles to tangents and normal to curves at every staked point on the "L" profile line. Determine the elevations of significant breaks in topography, breaks in the designed roadway template, and cross-section reference points. Record ground shots for these cross sections in terms of meters plus or minus from ground at centerline, and horizontal distances from centerline. Measure cross sections and record them to the nearest 10 mm in elevation and to the nearest 100 mm in horizontal distance. Ensure that cross sections extend approximately 6 m beyond the designed clearing-and-grubbing limit on cut sections, and approximately 6 m beyond the toe of fill on fill sections.

Identify cross sections at each end with lath marked to show centerline station and the horizontal and vertical distance to the centerline.

Return cross-section data to the CO for recomputation of earthwork quantities and slope stake catchpoint printouts. If the PAY ITEM for earthwork under Section 203 is Staked Quantities, submit the cross-section data to the CO for recomputation of earthwork quantities and slope stake "catchpoints."

Slope stakes established during the "L" topography cross section phase of the work may be subject to relocation to adjust earthwork quantities.

170.13 Slope Stakes, Clearing Limits, & Reference Stakes. Establish slope catchpoints, clearing limits, and slope reference stakes on both sides of the centerline at each "L" station established. Determine the position of these stakes by methods that will produce on the ground the designed template shown in the slope stake survey notes to the precision shown in table 170-2 and DESIGNATED IN THE SCHEDULE OF ITEMS.

Record the cut or fill and horizontal distance to centerline, to bottom of ditch, or to shoulder as designated by the CO on the slope stakes and in the slope stake notes, as shown in figure 170-1.

Set clearing limits on both sides of the centerline at each established "L" station within the tolerance shown in table 170-2. Locate the clearing limit on the ground to the dimensions SHOWN ON THE DRAWINGS and mark with lath, flagging, or other methods approved by the CO. Record the total horizontal distance from the centerline to the clearing limit at each section to the nearest 300 mm in the field book.

Establish slope reference stakes at a minimum horizontal distance of 3 m outside the clearing limits, and record on the stakes the horizontal distance to centerline and the vertical distance to the construction grade at centerline. In addition, record on the reference stake, and in the slope stake book, the offset from the slope stake catchpoint, and slope stake catchpoint information, as shown in figure 170-1.

Ensure that the elevation and location of slope reference stakes comply with the precision class specified in table 170-2.

Reset the slope stake where the difference in reference stake elevation between that established by slope staking and that observed by an elevation survey exceeds the allowed tolerance.

170.14 Monuments of Property Boundaries or Surveys. If property boundary or survey monuments, or survey markers, are found within or adjacent to the construction limits, immediately notify the CO.

170.15 Staking Culverts. Set slope stakes and slope reference stakes at all culvert locations. Set a culvert reference stake and hub on the centerline of the culvert 3 m from each end, or beyond the clearing limit, whichever is greater. Record the following on these stakes:

(a) Diameter, actual field measured length, and type of culvert.

(b) The vertical and horizontal distance from hubs to the invert at the ends of the culvert.

(c) Stationing of centerline point.

When SHOWN ON THE DRAWINGS, stake headwalls for culverts by setting a hub with a guard stake on each side of the culvert on line with the face of the headwall. (Perform this work after clearing is completed.)

170.16 Staking Drain Dips. Establish slope stakes and slope reference stakes on the projected centerline of the bottom of the dip at all drain dip locations, as SHOWN ON THE DRAWINGS.

170.17 Staking Major Structures. Meet the following requirements for staking bridges, cattleguards, and other structures:

(a) Bridges. Designate bridge locations on the ground by establishing reference points for the bridge centerline and the transverse centerline of each pier or abutment. Use hubs and tacks that are set on line beyond the construction limits as reference points, and mark them to identify the point and distance to the point referenced. Set at least one bench mark on each side of the stream beyond construction limits, but close enough to the bridge site to allow direct leveling between the bench marks and the bridge without an intermediate setup. Record all of the above information in a separate book that includes a sketch showing the stream, bridge, and location of all construction stakes set. Perform staking to the accuracy standards shown in table 170-1.

(b) Cattleguards. Stake cattleguards as SHOWN ON THE DRAWINGS.

(c) Other Structures. When required, stake other structures as described in SPECIAL PROJECT SPECIFICATIONS and/or as SHOWN ON THE DRAWINGS.

170.18 Grade Finishing Stakes. Set finishing stakes when DESIGNATED IN THE SCHEDULE OF ITEMS. Use blue tops for subgrade finishing stakes, and red tops for base course finishing stakes.

Ensure that stakes are nominal 25 x 25-mm hubs of sufficient length to provide a solid set.

Place finishing stakes on the staked cross section and road template line. Set a stake at each shoulder and at centerline. Set additional stakes when SHOWN ON THE DRAWINGS.

Set finishing stakes when subgrade is within 150 mm, or when base course is within 60 mm of final grade. Set stakes to the nearest 6 mm of the measured grade line.

170.19 Marking Stakes. Legibly mark all stakes in the format that is shown in figure 170-2, or as SHOWN ON THE DRAWINGS, with a stake pencil that leaves an imprint or with waterproof ink. Mark in conformance with the following nomenclature:

PI	Point of intersection of tangents
PC	Point of curvature
POC	Point on curve

PT	Point of tangency
POT	Point on tangent
RP	Reference point
P	P-line (preliminary location line)
L	L-line (final location line)
BM	Bench mark
TBM	Temporary bench mark
BT	Begin taper (any)
ET	End taper (any)
BFTO	Begin full turnout
EFTO	End full turnout
BFEW	Begin full extra widening
EFEW	End full extra widening
DD	Drain dip
C	Cut
F	Fill
℄	Centerline
D	Ditch
W	Width
CW	Curve widening
FW	Fill widening
H	Horizontal
M	Metric
SE	Superelevation
V	Vertical

170.20 Stake Approval & Maintenance. Do not begin construction work within a roadway segment until the stakes, marks, and controls established have been approved in writing by the CO. The minimum segment for approval shall be 1 km or the length of the project, whichever is less.

Approval of construction staking shall not relieve the Contractor of responsibility for maintaining the survey work and for correcting errors, whether the errors are discovered during the actual survey work or in subsequent phases of the project. Stakes within the roadway need not be maintained after clearing operations have started.

Measurement

170.21 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Reestablishing P-line includes all work needed to replace missing portions of the P-line that are necessary for the determination of L-line tangents. When DESIGNATED IN THE SCHEDULE OF ITEMS, the quantity shall be the number of kilometers of P-line reestablished, as measured along centerline to the nearest

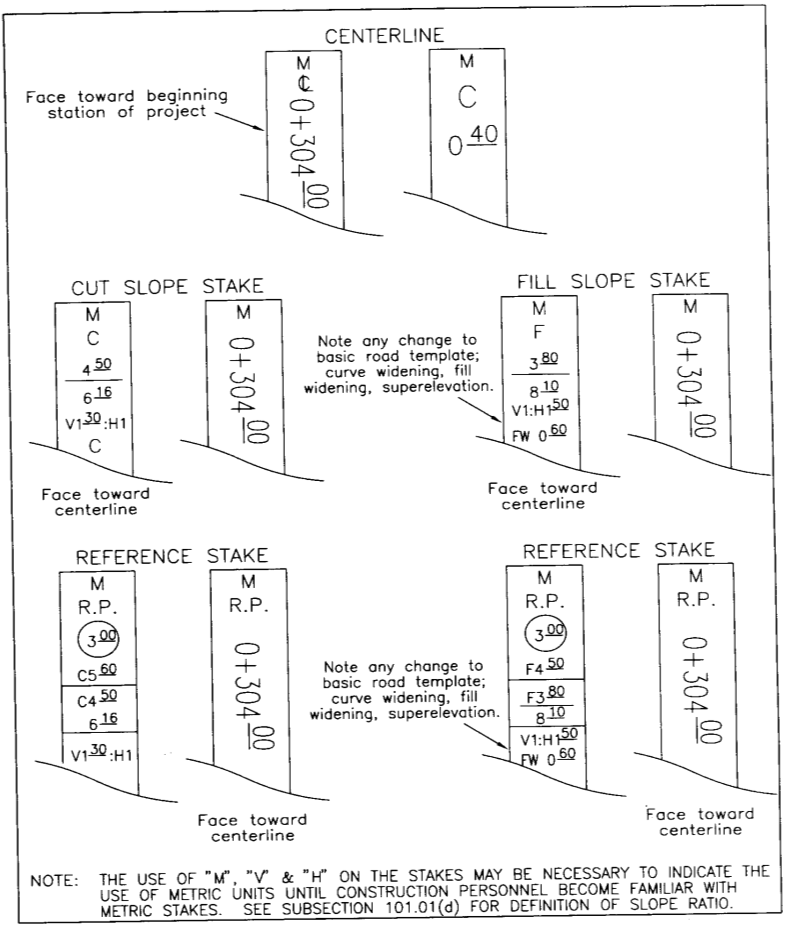

Figure 170-2.—Construction stakes.

5 m. When the length of P-line to be replaced does not exceed 10 percent of the measured length of the L-line, reestablishing P-line shall be considered incidental to establishing centerline, and no separate payment will be made.

Establishing centerline includes all work necessary to establish and reference the centerline, establish vertical controls, determine the centerline profile elevations, and cross-section the original ground from the centerline datum established by this survey. The quantity shall be the number of kilometers of centerline completed and accepted, as measured along centerline to the nearest 5 m.

Slope staking includes all work necessary to establish slope stakes, clearing limits, and reference stakes from a previously established centerline. The quantity shall be the number of kilometers of previously established centerline completed and accepted, as measured along centerline to the nearest 5 m.

Finish staking includes all work necessary to reestablish the centerline to control placement of finish stakes and set the finish stakes. The quantity shall be the number of kilometers of previously established centerline that were completed and accepted, as measured along centerline to the nearest 5 m.

Staking major structures includes all work necessary to establish lines and grades for the construction of the structure(s). The quantity shall be the actual number of structures completed and accepted of the type DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment

170.22 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item	Pay Unit
170 (01) Reestablish P-line, precision _____	Kilometer
170 (02) Establish centerline, precision _____	Kilometer
170 (03) Slope staking, precision _____	Kilometer
170 (04) Finish staking, subgrade, precision _____	Kilometer
170 (05) Finish staking, base course, precision _____	Kilometer
170 (06) Staking major structure(s), type _____ precision _____	Each

Section 171—Construction Staking, Offset L-Line

Description

171.01 Work. Complete the construction staking of a road project in accordance with the drawings and specifications. Furnish all labor, equipment, instruments, materials and transportation, and other incidentals necessary to complete the construction staking in accordance with these specifications and acceptable engineering practice.

Conduct construction staking under the direction of a licensed professional engineer or land surveyor who is closely associated and familiar with the construction staking. Periodic visits to the project site are required.

Materials

171.02 Stakes. Provide stakes and hubs that have the nominal dimensions SHOWN ON THE DRAWINGS or stated in the SPECIAL PROJECT SPECIFICATIONS. Ensure that identification stakes and hubs are of sufficient length to provide a solid set in the ground and space for marking above ground when applicable. Other dimensions and materials may be used if approved in writing by the CO. Paint the top 50 mm of all stakes and lath, or mark them with plastic flagging. Use colors for paint or flagging as SHOWN ON THE DRAWINGS or as stated in the SPECIAL PROJECT SPECIFICATIONS.

171.03 Survey Note Paper & Books. Furnish field notebooks or note papers. Use moisture-resistant paper for survey notes. Keep notes in books with covers that will protect the contents and retain the pages in numerical sequence during field use.

171.04 Government-Furnished Documents. Drawings, P-line survey notes, P-line to L-line offset data, construction staking notes, and the projected location of catch points will be furnished by the Government. Return one set of "as-staked" drawings and all documents to the CO.

Survey Requirements

171.05 Precision. Accuracy and precision requirements are contained in tables 171-1 and 171-2. Ensure that all work performed under this specification meets the requirements of the survey precision DESIGNATED IN THE SCHEDULE OF ITEMS or stated in the SPECIAL PROJECT SPECIFICATIONS.

171.06 Survey Notes. All notes will become the property of the Forest Service. Format slope stake notes in conformance with the format shown in figure 171-1.

Table 171-1.—Accuracy requirements for reestablishing P-line, traverse, and elevations.

Precision Class	Minimum Position Closure	Angular Accuracy (±)	L-Line Tangent Control Points[a] (±)	Vertical Closure[b] (±)
C	1/1,000	1 set, direct/reverse 1′ rejection limit	60 mm	500 mm/km
D	1/300	Foresight and backsight; 15’ rejection limit[c]	120 mm	1,000 mm/km
E	1/100	Foresight and backsight; 30’ rejection limit[c]	240 mm	1,000 mm/km

a. Accuracy of offset measurement.
b. Determine vertical closures at intervals not to exceed 1 km, as measured along centerline.
c. Magnetic attraction will require a deflection angle traverse.

The sketch in the lower half of figure 171-1 is for information only and is not required as part of actual slope stake note format. Other formats may be used if approved by the CO.

Print manually recorded survey notes in characters at least 4 mm high, and make them legible at a distance of 750 mm. Delete errors by lining out. At the beginning of each day’s work, record date, crew names and positions, instrumentation, and weather in the notes.

Consecutively number electronically recorded survey notes, and use headings to identify the contents. Support and accompany the notes with a bound Day Book that records the project name and, for each day, the date; crew names and positions; instrumentation; weather; type of survey; stationing of sections between which the survey was performed; and survey data or sketches that cannot be electronically recorded. Ensure that the party chief signs or initials the Day Book immediately after the last entry for each day’s work. When using electronic data collectors, have them approved by the CO, or provide suitable hardcopy notes.

Ensure that the party chief signs or initials each page of electronically recorded notes and the final page of bound notes immediately after the last entry for each day’s work.

Table 171-2.—Cross section and slope stake precision.

Item	Precision C (±)	D (±)	E (±)
Allowable deviation of cross-section line projection from a true perpendicular to tangents, a true bisector of angle points, or a true radius of curves	3°	5°	5°
Take cross-section topography measurements so that variations in ground from a straight line connecting the cross section points will not exceed	300 mm	450 mm	750 mm
Staking by computed			
Horizontal and vertical accuracy for cross sections, in millimeters or percentage of horizontal distance measured from traverse line, whichever is greater	45 mm or 0.6%	60 mm or 0.8%	90 mm or 1.0%
Horizontal and vertical accuracy for slope stake, slope stake references, and clearing limits, in millimeters or percentage of horizontal distance measured from centerline or reference stake, whichever is greater—			
Slope reference stakes and slope stakes	45 mm or 0.6%	60 mm or 0.8%	75 mm or 1.5%
Clearing limits	300 mm	450 mm	600 mm
Staking by catchpoint measurement method:			
Accuracy for setting slope catchpoints, reference points, and clearing limits, in millimeters or percentage of slope distance, measured from centerline, whichever is greater—			
Slope catchpoint stakes and reference points	45 mm or 0.5%	60 mm or 0.7%	90 mm or 2.0%
Clearing limits	300 mm	450 mm	600 mm

171.07 Reestablishing Preliminary Survey Line. A preliminary survey line has been established on the ground for this project, with initial and specific succeeding survey points referenced. Reestablish missing P-line points as necessary to control subsequent construction staking operations to the precision DESIGNATED IN THE SCHEDULE OF ITEMS, SHOWN ON THE DRAWINGS, or stated in the SPECIAL PROJECT SPECIFICATIONS.

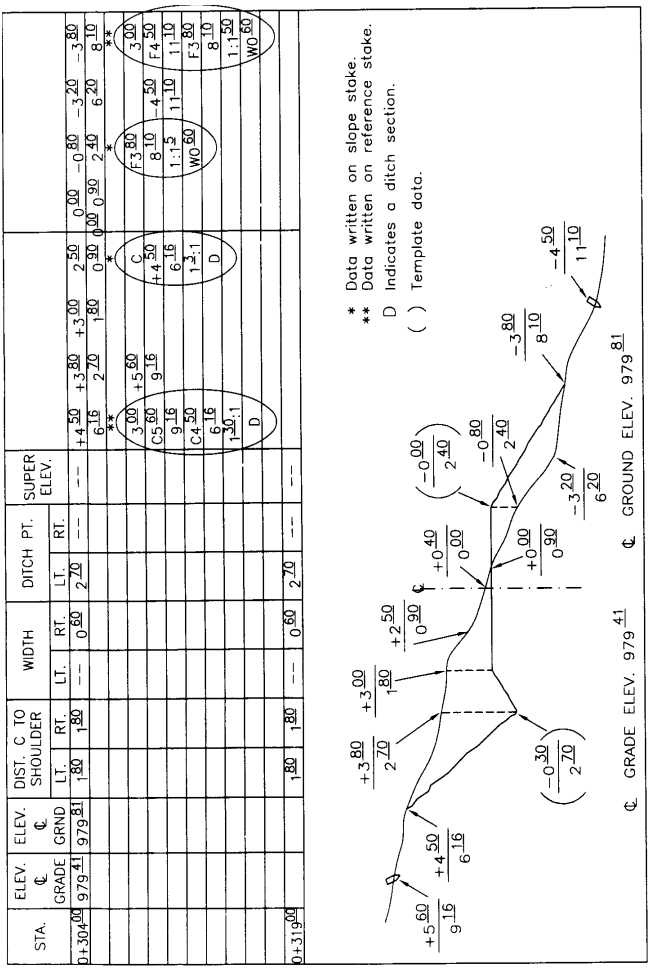

Figure 171-1.—Slope stake note entries related to actual ground elevations.

171.08 Establishing Centerline. Establish the position of the centerline (L-line) by measuring right or left from the preliminary survey line (P-line) the horizontal distance shown in the "offset listing" furnished by the Forest Service. Adjust the centerline established in alignment only to correct misalignment created by measured offsets along skewed sections. Ensure that the station of the centerline point is that listed in the P-line to L-line offset data.

Set additional intermediate centerline stakes at locations SHOWN ON THE DRAWINGS and listed in the construction staking notes, as needed to establish control for beginning and ending of extra widening and turnout tapers; for the beginning and end of full-width extra widening and turnouts; for crest and sag of drainage dips; for culvert catch basins; and for turnarounds. Establish the position and ground elevation of these additional stakes by measuring from the nearest established centerline stake.

Where centerline stations fall in an existing trail, roadway, or obstruction, offset the stakes right or left from centerline (perpendicular to tangents and on the bisector of angle points) and the distance marked on the side of the stake facing centerline. Drive suitable markers on the centerline to denote the actual centerline point.

Clear the survey line to facilitate surveying. Remove clearing slash from the travel or work area. Cut brush and trees as near to the ground as possible.

171.09 Vertical Control & "L" Profile Levels. Relocate bench marks that were established during the P-line survey within the clearing limits to points 6 m or more outside the clearing limits. Determine elevation of relocated bench marks by the precision class specified, as listed in table 171-1.

Construct bench marks to be permanent and to allow a level rod to stand vertically and squarely on the mark. Bench marks may be established by driving a 40-penny or larger nail into a notch cut in the base of a tree, by marking a point on a stable rock, or by other approved means. Drive spikes into trees less than 300 mm above the ground. Record location and descriptions of relocated bench marks in the level notes.

Use appropriate survey equipment between bench marks to determine centerline ground elevations on L-line stations, to the nearest 30 mm, and to verify bench marks.

For precision C and D, determine elevation of centerline stations by leveling from the listed elevation of the P-line station from which they were offset.

171.10 Discrepancies. Refer to the CO any differences that exceed 5° of angle in horizontal alignment of curves with less than 30 m radius found between the data SHOWN ON THE DRAWINGS and those observed on the ground.

Compare the found centerline cut and fill depth with design data. Report differences in centerline profile elevations exceeding 300 mm at any two or more consecutive points to the CO, who will determine whether revision is needed. Defer staking of these areas until these differences are resolved by the CO.

Check horizontal distances on the centerline by measuring between stakes on L-line. If discrepancies in actual distances measured are greater than 1.5 m, report them to the CO for possible corrective action.

171.11 Slope Stakes, Clearing Limits, & Reference Points. Establish slope stakes, clearing limits, and slope stake references at each side centerline station, as SHOWN ON THE DRAWINGS; at each centerline station; on a line at right angles to tangents; and on the radial lines of curves. Use a method to establish the slope stake catchpoint that conforms to the METHOD described below, as DESIGNATED IN THE SCHEDULE OF ITEMS.

(a) Method I—Computed Method. Locate slope stake catchpoints by using the template information shown in the slope stake notes to calculate the actual location of the catchpoint. The slope stake "catchpoint distance" shown in the stake notes may be used as a trial location to initiate slope staking.

Where SHOWN ON THE DRAWINGS, measure topography of the cross section at each centerline stake. Record the horizontal and vertical distance to the centerline ground for each break in ground slope between the centerline and the reference point(s).

(b) Method II—Slope Distance Measurement Method. Locate slope stake catchpoints by measuring the slope distance shown in the slope stake notes.

(c) Method III—Catchpoint Measurement Method. Locate slope stake catchpoints and clearing limits by measuring the "catchpoint distance" shown in the slope stake notes.

(d) Method IV—Reestablishing Slope Stakes, Clearing Limits, & References. Slope stakes and marks previously established for this project have either been destroyed or have become unreadable. Reestablish the missing stakes and marks from the original slope stake notes, as described in the SPECIAL PROJECT SPECIFICATIONS.

Mark clearing limits with colored plastic ribbon or tags on trees to be left standing, or on lath.

Place a reference stake or tag for each slope stake 3 m outside the clearing limit as SHOWN ON THE DRAWINGS. Remove slope stakes to the reference stake prior to clearing, and replace them after clearing is completed.

Set slope stakes temporarily at the slope stake catchpoint location established under method I, II, or III above for use in determining clearing limits and slope stake references.

Locate clearing limits at the distance SHOWN ON THE DRAWINGS from either the slope stake catchpoint or road shoulder, whichever is greater. Mark clearing limits with plastic flagging or tags on trees to be left standing, or on lath.

After clearing limits and references are established, move the slope stakes to the reference stake, and replace them at the catchpoint after clearing is completed.

171.12 Resetting Slope Stakes. Reestablish slope stakes after clearing and grubbing is completed and before excavation is started. Recheck the original catchpoint location from the reference stake to determine whether revisions are needed because of ground disturbance; recheck slope stakes and reset them to the original precision requirements.

171.13 Monuments of Property Boundaries or Surveys of Other Agencies. If property boundary or survey monuments or survey markers of other agencies are found within or adjacent to the construction limits, immediately notify the CO.

171.14 Staking Culverts. Set slope stakes and slope stake references at all culvert locations. Set a culvert reference stake on the centerline of the culvert 3 m from each end or beyond the clearing limit, whichever is greater. Record the following on these stakes:

(a) Diameter, actual field measured length, and type of culvert.

(b) The vertical and horizontal distance from the reference stake to the invert at the ends of the culvert.

(c) Stationing of centerline point.

171.15 Staking Drain Dips. Establish slope stakes and slope stake references on the projected centerline of the bottom of the dip at all drain dip locations, as SHOWN ON THE DRAWINGS.

171.16 Staking Structures. Stake cattleguards and other structures as described in the SPECIAL PROJECT SPECIFICATIONS or as SHOWN ON THE DRAWINGS.

171.17 Marking Stakes. Legibly mark all stakes in the format shown in figure 171-2, or as SHOWN ON THE DRAWINGS, with a stake pencil that

leaves an imprint or with waterproof ink. Mark in conformance with the following nomenclature:

RP	Reference point
P	P-line (preliminary location line)
L	L-line (final location line)
BM	Bench mark
TBM	Temporary bench mark
BT	Begin taper (any)
ET	End taper (any)
BFTO	Begin full turnout
EFTO	End full turnout
BFEW	Begin full extra widening
EFEW	End full extra widening
DD	Drain dip
C	Cut
F	Fill
℄	Centerline
D	Ditch
W	Width
CW	Curve widening
FW	Fill widening
H	Horizontal
M	Metric
SE	Superelevation
V	Vertical

171.18 Stake Approval & Maintenance. Do not begin construction work within a roadway segment until the stakes, marks, and controls established have been ap-proved in writing by the CO. The minimum segment for approval shall be 1 km or the length of the project, whichever is less.

Approval of construction staking shall not relieve the Contractor of responsibility for maintaining the survey work until construction has been completed, and for correct-ing errors, whether the errors are discovered during the performance of survey or in subsequent phases of the project. Centerline stakes need not be maintained after clearing operations have started.

Measurement

171.19 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

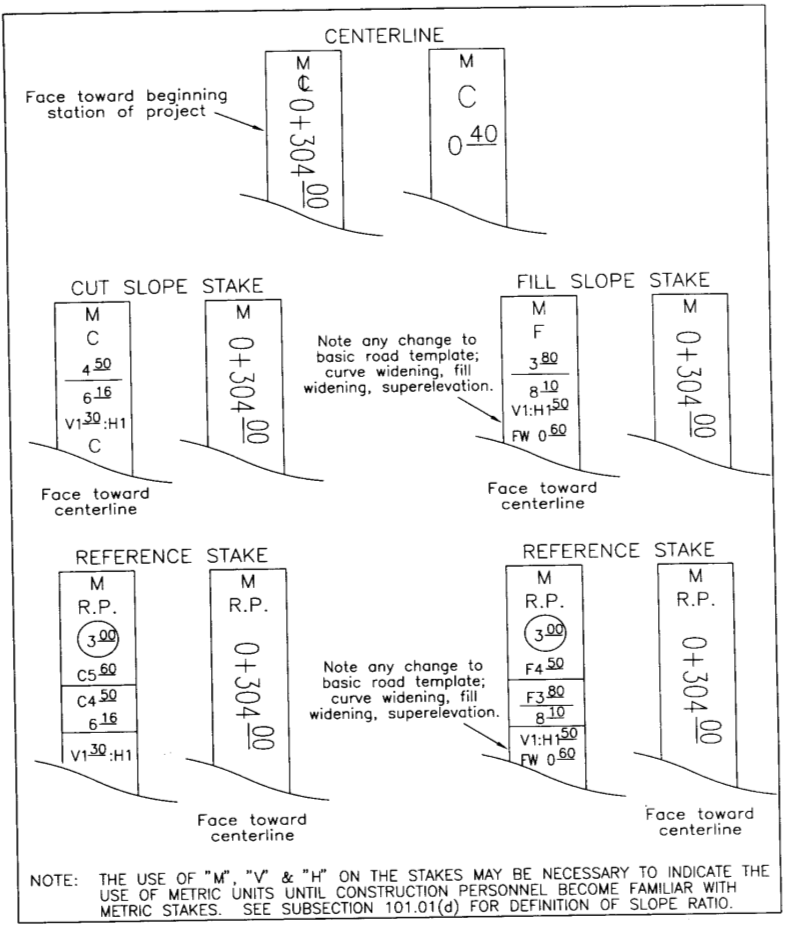

Figure 171-2.—Construction stakes.

Reestablishing P-line includes all work needed to replace missing portions of the P-line that are necessary for the determination of L-line tangents. When listed in the SCHEDULE OF ITEMS, the quantity shall be the number of kilometers of P-line reestablished, as measured along centerline to the nearest 5 m. When the length of
P-line to be replaced does not exceed 10 percent of the length of the P-line, reestablishing P-line shall be considered incidental to construction staking, and no separate payment will be made.

Construction staking includes all work necessary to establish the project centerline and to establish slope stakes, clearing limits, and reference stakes in accordance with the METHOD DESIGNATED IN THE SCHEDULE OF ITEMS. The quantity shall be the number of kilometers of construction staking completed and accepted, to be measured along the centerline to the nearest 10 m.

Payment

171.20 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
171 (01)	Reestablish P-line, precision _____	..... Kilometer
171 (02)	Construction staking, precision _____, method _____	..... Kilometer
171 (03)	Staking structures, precision _____, method _____	..... Each

Section 173—Construction Staking, Location Line

Description

173.01 Work. Complete the construction staking of a road project that will be constructed predominantly by sidecast or end-dump construction methods. Establish clearing limits and staking of drainage structures. Establish slope stakes for cuts and fills when SHOWN ON THE DRAWINGS. The survey required by this specification may be used in conjunction with other specifications in specific areas SHOWN ON THE DRAWINGS in order to produce staking adequate for construction needs.

Furnish all labor, equipment, instruments, materials, transportation, and other incidentals necessary to complete the construction staking in accordance with these specifications and acceptable engineering practice.

Perform construction staking under the direction of a licensed professional engineer or land surveyor who is closely associated and familiar with the construction staking. Periodic visits to the project site are required.

Materials

173.02 Stakes. Provide stakes that have the nominal dimensions SHOWN ON THE DRAWINGS or stated in the SPECIAL PROJECT SPECIFICATIONS. Ensure that identification stakes are of sufficient length to provide a solid set in the ground and space for marking above ground when applicable. Other dimensions and materials may be used if approved in writing by the CO. Paint the top 50 mm of all stakes and lath, or mark them with plastic flagging. Use colors for paint or flagging as SHOWN ON THE DRAWINGS or as stated in the SPECIAL PROJECT SPECIFICATIONS.

173.03 Survey Note Paper & Books. Use moisture-resistant paper for survey notes. Keep notes in books with covers that will protect the contents and retain the pages in numerical sequence during field use.

173.04 Government-Furnished Documents. Drawings, P-line survey notes, and, where applicable, construction staking notes will be furnished by the Government. Return all documents to the CO.

Survey Requirements

173.05 Precision. Use a woven or fiberglass/plastic tape in good condition and a hand level or abney, or other instruments capable of attaining the same accuracy of measurement.

173.06 Survey Notes. Neatly record survey notes in a standard format approved by the CO. Make lettering at least 4 mm high and legible at a distance of 750 mm from the eye. Delete errors by lining out. Certify all field notes as to originality. All field notes will become the property of the Forest Service.

173.07 Location Survey Line. A location line for this project has been established on the ground.

173.08 Clearing Limits. Establish clearing limits on each side of the location line by measuring the horizontal or slope distances as shown in the stake notes. Mark the clearing limits with flagging or tags on trees to be left standing, or on lath. Make markings intervisible, and in no case more than 30 m apart. Use colors for flagging or tags as SHOWN ON THE DRAWINGS or as stated in the SPECIAL PROJECT SPECIFICATIONS.

After establishing clearing limits, move the location line stake outside the clearing limits for station identification purposes, and mark it with horizontal distance to location line.

173.09 Slope Stakes & References. When SHOWN ON THE DRAWINGS, locate slope stakes on designated portions of the road. Locate the slope stake catchpoints and use them to establish clearing limits and slope stake references. Use a method to establish the slope stake catchpoint that conforms to the METHOD described below, as DESIGNATED IN THE SCHEDULE OF ITEMS.

(a) Method I—Computed Method. Establish slope stake catchpoints by using the template information shown in the slope stake notes to calculate the actual location of the catchpoint. The slope stake "catchpoint distance" shown in the stake notes may be used as a trial location to initiate slope staking.

(b) Method II—Catchpoint Measurement Method. Determine the location of slope stake catchpoints by measuring the catchpoint distances shown in the stake notes.

Place slope stakes as SHOWN ON THE DRAWINGS. Ensure that slope stakes indicate the station, the amount of cut or fill in meters, the horizontal distance to centerline in meters, and the cutslope or fillslope ratios.

Place slope reference stakes a minimum of 3 m outside the clearing line, and marked with the offset distance to the slope stake.

Prior to clearing and grubbing operations, move the slope stake outside the clearing limit to the slope reference stake. After clearing and grubbing and before excavation, reset the slope stakes in their original position.

173.10 Monuments of Property Boundaries or Surveys. If property boundary or survey monuments, or survey markers, are found within or adjacent to the construction limits, immediately notify the CO.

173.11 Staking Culverts. Set culvert reference stakes at all culvert locations. Set a culvert reference stake on the centerline of the culvert 3 m from each end or beyond the clearing limit, whichever is greater. Record the following on these stakes:

(a) Diameter, design length, and type of culvert.

(b) The horizontal distance from the reference stake to the invert at the ends of the culvert.

(c) Stationing of centerline point.

173.12 Staking Drain Dips. Establish reference stakes outside the clearing limits on the projected centerline of the bottom of the drain dip at all drain dip locations, as SHOWN ON THE DRAWINGS.

173.13 Staking Cattleguards. Stake cattleguards as SHOWN ON THE DRAWINGS.

173.14 Marking Stakes. Mark all stakes with a stake pencil that leaves an imprint, or with waterproof ink, in a format approved by the CO.

173.15 Approval & Maintenance. Do not begin construction work within a roadway segment until the stakes and marks established are approved in writing by the CO. The minimum segment for approval shall be 1 km or the length of the project, whichever is less.

Approval of construction marking or staking shall not relieve the Contractor of responsibility for maintaining the survey work until construction has been completed and accepted, and for correcting errors, whether the errors are discovered during the performance of the survey or during subsequent phases of the project. Location line stakes need not be maintained after clearing operations have started.

Measurement

173.16 Method. Use the method of measurement that is DESIGNATED IN THE SCHEDULE OF ITEMS.

Construction staking includes all work necessary to establish slope stakes, clearing limits, and slope stake references. The quantity shall be the number of

kilometers of construction staking completed and accepted, as measured along centerline to the nearest 10 m.

Payment

173.17 Basis. The accepted quantities will be paid for at the contract unit price for each PAY ITEM DESIGNATED IN THE SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item	Pay Unit
173 (01) Establish clearing limits _____	Kilometer
173 (02) Establish slope stakes, method _____	Kilometer