

## Chapter 2 - Construction Surveys

### ***2-201 Survey Parties***

The duties and responsibilities of survey crews and the types of construction surveying performed is covered in this chapter. The discussion applies to surveying performed by Department forces or consultant or contractor personnel.

#### ***2-201A Responsibilities and Duties of Survey Parties on Construction Projects***

Survey parties are assigned to construction projects by and are under the direction of the Principal Engineer—Surveys or authorized representative. Responsibilities include the following activities.

- Setting stakes for lines and grades on all construction and reconstruction projects within the District, when required by the contract.
- Spot-checking layout and staking performed by contractor forces when construction staking is a part of the contract.
- Performing field work and office computations to quantify volumes for partial and final payments, when not performed by the Inspector.
- Staking for fencing or other purposes along property lines, highway lines, or non-access lines (Department forces only).
- Integrating activities with other sections of the unit, through the Principal Engineer—Surveys in the District Office.
- Field checking existing or resetting sufficient control points and bench marks so that contractors can provide their own staking, when called for in the contract.
- Tying in existing street, highway and private property line monumentation as required.

#### ***2-201B Responsibilities and Duties of Chief of Party***

On construction projects to be staked by the Department, the assigned Chief of Party is responsible to the Chief Inspector while at the construction site. Duties include:

- staking out projects in accordance with the plans,
- establishing and maintaining all necessary controls,
- obtaining measurements and other information,
- submitting reports showing results of work performed, and
- ensuring that sufficient stakes are set to enable the contractor to proceed with regular work to complete the project as scheduled.

Prior to starting any field work, the Chief of Party must thoroughly examine the special provisions of the contract, which are available at all times in the District Office files, and the plans of the project to become thoroughly familiar with the proposed work.

The Chief of Party will, in addition to setting the original stakes, make special measurements, take cross sections, and give line and grade for special work as requested by the Inspector, either directly or through the Field Supervisor—Surveys. The Chief of Party is governed in this work by the plans, special provisions, specifications, original design computations, and any special instructions from the Field Supervisor—Surveys.

If contract documents require construction staking to be done by the contractor, sufficient checks must be made by the State or consultant survey party to determine that the work is done in conformance with the plans, specifications, and special provisions.

Should an error or variations from the contract documents in layout be observed, the Chief of Party must immediately notify the Project Engineer or designated representative. Under no circumstances is the Chief to coordinate the finding with the contractor or consultant without first notifying the Field Supervisor—Surveys.

The Chief of Party will cooperate with the Chief Inspector at all times and acquaint the Inspector with the locations of all points and the extent to which the work is covered by surveys. All dealings with the contractor or the contractor's representatives are through the Chief Inspector.

When the survey party arrives at a construction site and it is determined that insufficient field work is available to accommodate the entire workday, the Chief of Party will call the District Surveys Office for assignments for the remaining portion of that day.

### ***2-201C Assignment of Survey Parties***

When surveying is needed on a construction project, the Project Engineer requests a survey party through the Field Supervisor—Surveys. The Principal Engineer—Surveys must keep abreast of all construction survey requirements and meet such requests within the required advance notification period so that all surveying schedules can be met. Survey parties may be requested on shorter notice, if the nature of the work requires it. However, requests of this type should be kept to a minimum.

Construction surveys should be scheduled to provide a full day's work on the project, if practicable. The estimate for the extent of an assignment must consider travel time to and from the project, as well as additional work on the project or other projects nearby. If construction survey work requires only a portion of a day, the Survey Section will arrange for additional location or right-of-way survey work, as near to the construction site as possible, to make use of the remaining time for that day. The coordination of the work is accomplished through communication between sections. If a request is made for a survey party for construction staking, the request must contain the following information:

- the project number,
- the project location,
- the anticipated length of time the survey party will be needed,
- the nature of the work to be accomplished,
- the Chief Inspector's name,
- the telephone number at the project, if one is available, and
- any other applicable special instructions that affect the type and amount of equipment, material and personnel required to accomplish the assignment.

Immediately upon receipt of plans and a copy of the advertisement for letting of a contract, the Principal Engineer of Survey and Plans prepares a Work Order for construction surveys and incidentals. Upon receipt of the Work Order, assigned field parties perform the work necessary to reestablish the field controls from the plans and preliminary survey notes. The scope of work may vary among projects, depending on the special provisions. The assignments are made

well in advance of the start of construction, to allow the Chief of Party time to check all data shown on the plans and to establish controls in the field prior to the start of construction operations.

### ***2-202 Survey Equipment***

#### ***2-202A Assignment of Field Party Equipment***

Field engineering equipment is assigned to the Chief of Party, who is responsible for its care and use. The Chief of Party is also responsible for having complete equipment and sufficient supplies on the project to perform all the work required.

#### ***2-202B Use of Equipment***

- The Chief of Party is responsible for the maintenance and accuracy of all assigned equipment.
- If an instrument becomes damaged or is in need of repair, the Principal Engineer—Surveys will make arrangements for the necessary repairs.
- A total station must be checked at a calibration range approved by the Department's Office of Central Surveys prior to the start of survey activities.

All equipment is inspected periodically by the Principal Engineer—Surveys. The Chief of Party is responsible for any neglected or abused equipment. Each Chief of Party must submit a complete inventory of all assigned equipment to the Principal Engineer—Surveys, when required.

#### ***2-202C Transporting Equipment***

Chiefs of Party ordinarily carry all necessary equipment in survey vehicles (vans), so it is available at all times in case it is needed. Extreme care must be exercised in packing equipment in the vehicle so that such articles as level rods, line rods, tripods, and similar items will not be damaged by scratching or rubbing. Instruments must never be transported by placing them on the floor or seat of a vehicle. They are placed in the special compartment in the survey vehicle. If it becomes necessary to transport instruments for long distances, they must be placed in their cases and in additional shipping cases, and further protected from damage by placing them so they will receive the least possible jar and vibration.

#### ***2-202D Damage to Equipment***

If equipment is damaged or destroyed through carelessness, or through inexcusable or avoidable accident, the employee responsible will be charged with the cost of making the necessary repairs. Damage to equipment, whether caused by accident or carelessness, must be reported immediately through the immediate supervisor to the head of the Division. Damage to State equipment or property that does not involve outside parties or personal injuries is reported on Form PRO-57.

### ***2-203 Safety and Traffic Control***

- Safety vests, hard hats, and foot protection are worn by all employees working in the field.
- The Chief of Party is responsible for setting and maintaining work area signs and signing patterns required for surveying operations. Refer to the *Manual on Uniform Traffic Control Devices (MUTCD)* flagging and signing requirements.
- Flaggers must be used to control traffic and protect survey personnel.
- Flaggers should be stationed in advance of the work. They should face the oncoming traffic and perform their duty diligently while the work is being performed. They should move to the side of the road whenever the crew and equipment temporarily move off the roadway area.
- Members of the survey party serving as flaggers are required to use safety paddles to signal and control traffic. See Chapter Eleven, “Construction Traffic,” for signaling methods.

**NOTE:** The setting of complex or long traffic patterns is usually performed by the contractor or Maintenance Department.

### ***2-204 Note Keeping***

#### ***2-204A Standard Note Keeping***

All survey notes are recorded in standard Department field notebooks or electronic data collector files. Inscribe the name of the town or towns, the route number, and the name of the project on the top half of the outside front cover of the field book. Assign a number to each field book. The number consists of three parts: the number of the town, the serial number of the project in that town, and a letter of the alphabet. The first book used will have the suffix “A,” the second will have the suffix “B,” etc. On extremely large projects if more than 26 field books are used, the 27th book is numbered “AA,” the 28th is numbered “AB,” etc. Place the number on the front cover in the space provided and on the bound edge, using drawing ink.

The book title reference describes the material in the book, such as general information, level notes, borrow bank cross sections, embankment cross sections, or final measurements. The project number, book number, book title and volume coding is also placed on the flyleaf with a brief description of the notes contained in the book, such as the “I-84 —Towns of Manchester and Vernon—Construction Survey, Final Measurements.” The first ruled half sheet of the book is used to index the contents of the book.

If more than two field books are required for a project, each book should be indexed. In addition, a separate index book should be kept covering all information contained in the various books, by book number and page. In each notebook the right-hand page of the first full sheet is designated “Number 1,” and the double pages that follow it are numbered sequentially in the upper right-hand corner of the right-hand page of the book. Numbers always refer to the double page. Show the starting date of the survey on page 1. Each day that work is performed, show the date and the names and duties of each member of the survey party. The duties of party members are shown by the use of standard symbols.

#### ***2-204B Care of Notebooks***

Survey notebooks and electronic data collector files (hard copy download) are original records, and the greatest care should be exercised to prevent loss or damage to notebooks and files. If possible, they should be kept in a fireproof case or a vault. Each Chief of Party or other person using a notebook or computer file is charged with its safe custody and is responsible for returning it in good condition to the immediate supervisor. Do not leave field books in the field offices of the Inspector or contractor at any time. It is never permissible to remove pages from a notebook for any reason. If the

notes are obsolete or void, mark each page with crossed diagonal lines. Place the markings so that they do not obliterate any part of the notes. Add a reference for the correct book and page.

### ***2-204C Survey Notes***

For consistency and ease of use, all notes for construction surveys must follow the standard note keeping format. All data collection files will follow the format of its software. The data files accurately and completely record the work done and the information gained during the survey, so that any qualified Department instrument operator, draftsman, or engineer can immediately interpret their meaning. Chiefs of Party and other note keepers should strive to become proficient in keeping data according to the established standards.

Incomplete and illegible notes will not be tolerated. Notes are kept with a sharp, hard pencil of a degree of hardness warranted by the hardness and smoothness of the notebook paper. Ordinarily a 3H or 4H pencil should be used. In some cases, when paper is lightly damp, it may be necessary to use an H or 2H pencil. Never erase in a notebook. If a figure is recorded incorrectly, or if an error in computation is made, the incorrect figure should be crossed out in such a manner that it is still clearly distinguishable, and the correct figure should be written above. All sketching should be done with a proper note-keeper's tool. Freehand sketching should seldom if ever be used. All notes should be lettered. Clear, legible lettering of the type accepted as engineering lettering should always be used. As stated above, the first page of notes in the notebook must show a brief title of the day's work, the date, and the names and duties of the members of the party. For each successive day's work, if it is a continuation of the past day's task, the page need not be titled again. The date and names and duties of the party members is sufficient. The end of each day's work must be noted.

Field data should always be originals. If, because of weather or other conditions, it is not possible to keep clean, legible notes, note keeping should be discontinued until conditions are favorable. Never keep notes on a loose piece of paper to be later copied into the notebook. If it should be necessary to make copies of field notes, the copy must be distinctly marked to indicate the fact. When it becomes necessary to continue notes from one book to another, the books should be cross referenced. Place the number of the previous book on the first page of the book where the notes are continued, and place the number of the book where the notes are continued on the last page of the previous book.

When field data is collected electronically, a field book shall also be used. The field book shall still report the daily activities, survey party numbers and their duties. When collecting survey data electronically, it is imperative for accurate sketches of work locations and controls to be available for future reference.

### ***2-204D Notes for Bench Levels***

Three-wire leveling is normally used for control or shots where a high degree of accuracy is warranted. The single-wire method is used for all other control or shots. Trigonometric leveling can be substituted for either of the above methods if proper procedures are used. (See Location Survey Manual)

The left-hand page is used to record rod readings and elevations, and the right-hand page is used for the identification of bench marks, turning points, and other elevations taken during the survey. The location of any bench marks established must be described with sufficient accuracy so that they may be readily found for later work or by other parties. The bench mark must be clearly described and referenced to prominent witnesses. When the witnesses have not been located in the survey, the bench marks shall be referenced to stationing on the preliminary traverse line so that they can be easily located.

The following guidelines apply where new bench marks must be established on construction surveys.

- The distance between permanent bench marks should not exceed 800 ft. (250 m).
- The maximum difference in elevation between bench marks is 50 ft. (15 m).
- The bench mark should be located outside of the construction area.

- If suitable objects for bench marks do not exist, monuments or other rigid, permanent points must be set. These may consist of railroad spikes or other substantial objects driven into the root or base of a non-ornamental tree in excess of 12". Objects driven into utility poles are not acceptable as bench marks. (See Location Survey Manual for further detail.)

The elevation of newly established bench marks must be determined by using the bench mark as a turning point between existing bench marks.

### ***2-204E Cross Section Note Guidelines***

Follow these guidelines when taking cross sections manually in a field book.

- Write legibly. Do not make extremely small figures.
- Do not crowd notes. Allow ample room for the reduction of rod readings.
- The right-hand page is used only for Quantity Cross Sections.
- Other shots or sections that are taken for information purposes, not for quantity documentation, are kept on the left-hand page. These include skew sections, culvert sections, and short odd sections such as for driveways or profiles.
- If a section or a portion of a section is used as a back section and a portion or entire section is used as an ahead section, record the required information as two separate sections with a station differential of at least 0.03 ft. (0.01 m). This condition may occur at a bridge abutment if one section is needed to show the roadway and another to show the ground at the base of the abutment.
- The computer is not programmed to accept more than one elevation at a given point, such as occurs at curbs, retaining walls, and banks. In such instances, change the second distance so that it is longer by 0.03 ft. (0.01 m.) from the first
- Bench levels used to establish the H.I. (height of instrument) are shown on the left-hand page each time an H.I. is changed.
- The entire H.I. is shown on the bottom of each right-hand page. If the H.I. changes on the page, draw a dividing line across the page between the sections dividing the H.I.s and write the new H.I. just above the dividing line.

In summary:

- Keep the notes clear, neat and understandable.
- Record all data to be used for earthwork computations on the right-hand pages and all other data on the left-hand pages.
- Place any special explanatory notes necessary on the right-hand page and label them for the computer operator's attention by circling the item to make it conspicuous.

### ***2-204F Cross Section Notes (Level and Rods)***

Cross section notes, if levels and rods are used, are recorded using the guidelines below.

- The right-hand page is used only for cross sections to determine pay quantities.
- The bench levels used to establish the H.I. are shown on the left-hand page each time an H.I. is changed.

- Any rod readings or sections taken for informational purposes, rather than for quantity determination (skew sections, culvert sections, short odd sections for driveway profiles, etc.) are kept on the left-hand page.

### ***2-204G Notes for Bridge Staking***

All bridge staking notes are carefully recorded. Sufficient stakes are set and their exact position recorded so that any of the control lines can be replaced with a minimum of effort. If batter boards are set, stakes must also be placed so that the batter boards can be easily replaced or checked if they are destroyed or accidentally knocked out of position.

### ***2-204H Notes for Construction Stakes***

Notes for construction stakes are recorded as follows. On the left-hand page, record the stations and pluses, offsets, the elevations of the stakes, grades, stake markings, banks, and slope distance for the left side of the road. On the right-hand page, record the horizontal distance for the right side plus the offset, stake elevations, grades, stake marking, banks, and slope distance for the right side of the road.

### ***2-205 Computations***

All ordinary computations made for survey-type work, are made on standard 8½ in. × 11 in. (216 mm × 279 mm) or 11 in. × 17 in. (279 mm × 432 mm) computation sheets (Form DES-3A). Place the name of the project, the Work Order number, the signature of the computer, the organization unit number, the date and the purpose of the work in the designated position on the sheet before any work is done. The checker signs the sheet in the proper place after the computations are completed and correct. The sheets become part of the permanent records for the project and must be bound and kept in a fireproof place.

### ***2-205A Completeness of Computations***

Computations must be complete in every respect so that they can be checked readily by engineers not familiar with the project and so that their meaning will be clear at later dates when the details of the work have been forgotten. The steps in the computations must be explained, and all deviations from standard procedures must be carefully noted. Computations must be continued to a logical conclusion, and the results must be stated concisely.

### ***2-205B Revisions to Computations***

Preliminary computations that have been revised or recomputed shall be marked “obsolete” in red pencil but must remain a part of the file. No computations shall be destroyed without the express consent of the Principal Engineer—Surveys. Erasures are never permitted on computation sheets. If a change is required, the portion to be revised is struck out with a single line, and the new figure is placed above.

## 2-206 Staking

### 2-206A Staking Centerline

When construction staking is to be performed by the Department, the Project Engineer must notify the Field Supervisor—Surveys well in advance of the time the contractor wishes to commence construction operations. The contractor's starting date is a guide for scheduling the staking.

The Chief of Party stakes the centerline of the proposed road as indicated below.

- Stakes are set every 50 ft. (20 m) on the line.
- Centerline is indicated on the stakes by the use of tacks or marks to the nearest 0.01 ft. (3 mm) of true line and true distance. Other means of identifying the points may be used if the preservation of the points is not required.
- All stations are set using horizontal distances.
- On long tangents and curves, it is advisable to set tacked hubs every 50 ft. (20 m) or less, so that offset stakes may later be tacked to provide a means of resetting stakes accurately without excessively long runs to the control points. The tacked offset stakes should be tied to at least two durable references so that points can readily be replaced if destroyed during construction.
- Curves are staked from the data on the plans.
- Additional stakes are placed at curves if advisable to stake superelevation and widening.
- If construction staking is performed by the contractor, the Chief of Party reviews the staking to ensure that sufficient control points are established and referenced so that they will be readily available during the life of the project.
- Stakes are set at each station. The first substation after Station 10 + 00 is 10 + 50.
- Offset stakes with tacks are set on both sides of the proposed road, opposite each centerline point established during the staking of the line. Stakes 2 in. × 2 in. (45 mm × 45 mm), approximately 18 in. (450 mm) long, are driven about 12 in. (300 mm) into the ground at convenient points well outside the area that is likely to be disturbed during construction operations. Great care must be taken to place these stakes at right angles with the tangents and on radius lines for curves. Longer stakes are used in soft ground to ensure that they are firmly set.
- The horizontal distance from the tack to the centerline must be legibly marked in yards to the nearest inch on the back of the stake (the side away from the centerline). Mark the station number and plus on the side of the stake toward the beginning station. Mark the cut or fill on the front of the stake (the side toward the centerline), showing the vertical distance in yards and inches from the top of the stake to the finished pavement surface at the centerline. Stakes below these points are marked with an "F" to indicate fill, and those above the centerline elevation are marked with a "C" to indicate cut. The notes must show the exact position of each stake and the information recorded on it. Such information as superelevation and widening of curves is placed on the other side of the stake (opposite the station). Figure 2-2.1 shows the method for marking the four sides of an offset stake.
- All bench marks must be checked into when the levels are run to set the cuts and fills for the offset stakes. To avoid a blunder, close to a different bench than the one started from.

See Figure 2-2.2 for recommended stake standards.

Figure 2-2.1 Typical Offset Stake Markings

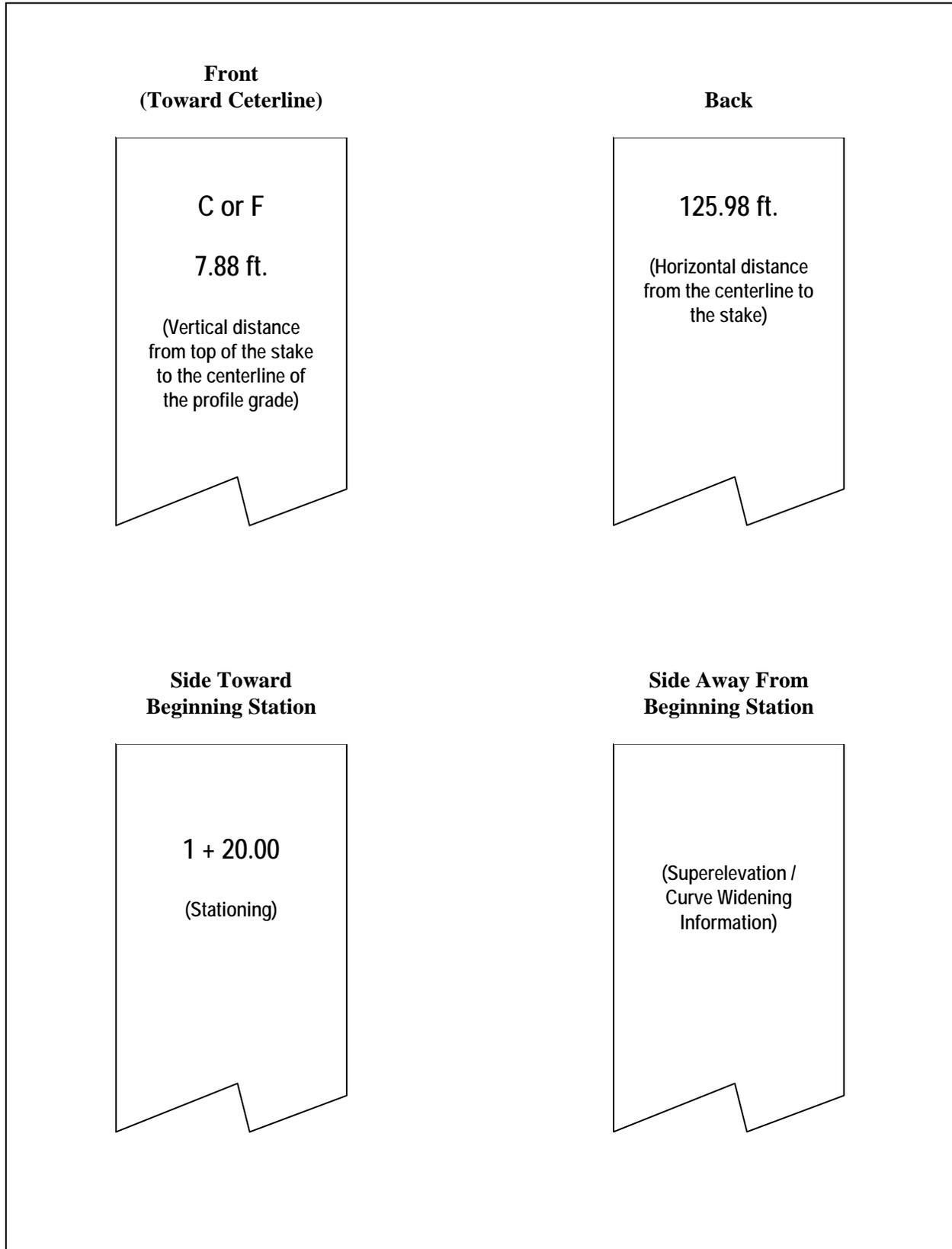


Figure 2-2.2 Recommended Stake Standards

	Stake Type	Horiz. Tolerance	Vert. Tolerance	Max. Spacing	Stake Notation		
					Front	Back	Left
Clearing Limits	3	1 ft.	n/a	100 ft.	Clearing limit		
Rough Grade (2) (4)	3	0.1 ft.	0.1 ft.	100 ft.	c/f	o/s	station
Fine Grade (1) (2) (4)	1	0.1 ft.	0.01 ft.	50 ft.	c/f	o/s	station
Centerline	1	0.1 ft.	n/a	50 ft.			station
Slope (2) (3)	1	0.1 ft.	0.1 ft.	50 ft.	o/s to intercept c/f total horiz. slope distance rate of slope	station	
Blue Tops (1) (2)	2	0.1 ft.	0.01 ft.	50 ft.	c/f	o/s < 5 ft.	station
Curb & Gutter (1) (2) (5)	2	0.01 ft.	0.01 ft.	5 ft.	o/s, c/f		
Pipe (6) (2)	4	0.01 ft.	0.01 ft.	100 ft.	c/f	o/s	station
Boundary	4	0.01 ft.	n/a	n/a			
Minor Structure (7) (2)	4	0.01 ft.	0.01 ft.	n/a	o/s	c/f	structure ID

- Stake Types**
1. 3/4" x 2" x 18"
  2. 2" x 2" x 12" or nails or stakes
  3. 3/4" x 2" x various
  4. 2" x 2" x 18" with tack, or 6" – 8" spike

- Notes**
- (1) Stakes placed on grade shall have an "X" marked on top of the stake and the word "Grade" written instead of "C" or "F."
  - (2) Elevations are measured to the top of the stake.
  - (3) Slope stakes should be set at a minimum of 10 ft. offset from the slope intercept.
  - (4) If the grade is less than 1 percent, the minimum stake spacing should be reduced.
  - (5) Grade is the top of curb; offset is the back of curb.
  - (6) All pipelines require at least two reference lines of 2 hubs, spaced 15 ft. apart.
  - (7) Reference lines are to center of junction box, drop inlet, CLCB, front face of headwall, or center gutterline CCB.

Stake standards adapted from *Manual on Construction Layout*, National Society of Professional Surveyors, 1993

**2-207 Cross Sections****2-207A Earthwork**

It is essential that accurate cross sections of the proposed improvements be available for determination of final pay quantities. The preliminary survey elevations, as plotted on the project's section sheets or taken from the computerized location survey surface, should be checked against the ground elevations recorded just prior to construction.

If there has been any change in the contour of the ground surface, new cross sections must be taken before construction starts. One example of the need to check the original cross sections is when they were taken when deep snow covered the ground with possible ice formation or frost heaves. If the original cross sections taken during the preliminary survey still show the true conditions, they may be used without further work. The checks of the original ground elevation should be made after the centerline or base line of each roadway is established and the offset stakes are placed, so that the sections can be checked at the correct angles with the centerline. It is recommended that ground elevation checks also be made along the slope limits. Particular attention should be given to areas where ground elevations vary considerably. All ground elevation checks should be recorded in a field book or electronic data-collector file and retained as part of the project records.

Cross sections are taken every 66 ft. (20 m) and at points between them where there is a break of grade or a change in the shape of road or embankment. The elevations of all breaks in grade on the cross section lines shall be determined and recorded as specified in the instructions for note keeping. The last reading on each cross section line must be well outside the proposed roadway limits. Sufficient cross sections must be taken in the transition areas between cuts and fills so that quantities can be accurately computed. Cross sections are required where side roads, driveways, or approaches must be constructed or where special structures are to be built. Cross sections are needed at culvert locations. If these cross sections were not taken during the preliminary survey or are insufficient for computing pay quantities, additional cross sections should be taken before construction commences.

Electronic data collectors can be used to process TIN files and create computerized cross sections. Sufficient shots and break lines must be collected to accurately create cross sections at all of the required locations noted in the previous paragraph.

**2-207B Rock Excavation**

When rock surface has been exposed and before rock excavation has begun, the survey party is called to the project to take cross sections manually or through electronic data collection for the determination of quantities. Careful cross sections of the rock shall be made on the same cross-section lines as the original sections and such intermediate lines as are necessary to determine accurately the quantity of the rock to be excavated. Cross sections are taken at intervals of not more than 33 ft. (10 m), unless the facial contour of the rock shows that additional sections are needed. If the excavation is bid by the contractor at the same unit price for rock and earth, sufficient data shall be kept to permit a reasonable estimate of the quantity of each.

**2-207C Unsuitable Material**

If unsuitable material or loam is encountered in the roadway, the survey party will take cross sections, both before and after excavation work, to determine the pay quantity.

**2-207D Borrow Banks**

The Project Engineer must notify the Principal Engineer—Surveys at least five days prior to obtaining material from borrow pits. All pits shall be cleared by the contractor prior to calling a survey party to the project. The Chief Inspector

will show the Chief of Party the limits of the proposed borrow pits. Base lines are laid out well beyond the limits of the pit, and control points are tied in. Bearings are taken on base lines and angles are turned to tie points, so that they can be reestablished at any time. At least two bench marks must be established at each borrow bank. Bench marks must be placed beyond the limits of the area to be excavated.

Cross sections are taken at 66 ft. (20 m) intervals, with sufficient intermediate sections taken to show the true contour of the ground. It is the District's duty to take its own borrow-bank cross sections and make its own computation of quantities removed from borrow banks, completely independent from the contractor's computations. However, contractors may request to check borrow-bank measurements. This can be accomplished by supplying them with the base-line data so that the cross sections will be related to the same base line. The data supplied to the contractor should be limited to base-line ties, stakes, and bench marks.

If the contractor has completed work, final sections are taken over the area excavated. The original base line must be reestablished so that cross sections can be taken in the same locations as those of the original sections, with intermediate sections taken as required to obtain accurate quantities.

The Chief of Party informs the Chief Inspector of the limits covered by the pit survey, and the Chief Inspector notifies the contractor that additional cross sections are required before the contractor excavates beyond existing surveyed limits.

Electronic data collectors can be used to process TIN files to create surfaces for surface-to-surface volume or cross sections. Sufficient shots and break lines must be collected to accurately create cross sections at all of the required locations mentioned above.

### ***2-207E Stakes for Concrete and Other High Type Pavements***

A second set of construction stakes is set if concrete and other high type pavements, curbs, or headers are to be constructed. One set of stakes is ordinarily sufficient for other work. These stakes are uniformly offset 2 to 4 ft. (600 to 1200 mm) outside of the edge of the pavement or the back of the curb or header. Stakes for curbs are marked to indicate the cut or fill to the top of the curb rather than the finished centerline elevation. Stakes for concrete pavement are marked with the amount of cut or fill from the highest point on the top of the stake to the elevation at the edge of the finished pavement surface. The position of the stake and the information recorded on it must be shown in the notes. The cut or fill is given in feet and hundreds (0.01 ft.)

### ***2-207F Staking Bridge Structures***

The centerline is determined for bridges by running the line between points of curvature and tangency of curves or between other established points so that the true centerline may be staked. The stationing must be carried from one known station and checked into at least one other station on the opposite side of the structure. The structure is located as shown on the plans, unless instructions to the contrary are received from the Project Engineer. The establishment of the centerline and the stationing of the structure must be checked in sufficient detail to make absolutely sure of its correct location.

The centerline of the roadway is carefully monumented by driving hubs at each side of the structure, well outside of the construction area, and parallel lines are run and monumented at even distances from the faces of the abutments. If possible, backsights are set on the lines so that the centerline and parallel lines can be reestablished, even if the foresights are blocked by material piles or embankments. The hubs are set and referenced to witnesses that are not likely to be disturbed during construction work. If this method is impractical, batter boards, with nails to mark the exact line, are placed at approximately equal distances from the centerline of the roadway on the lines of the faces of the abutments.

Batter boards are set at the elevation of the bridge seat if practical, and each batter board is marked to indicate the line and elevation represented. If the face of the abutment is battered, the line of the top of the abutment is staked. If the centerline stakes are likely to be disturbed, offset stakes on the line of the face of the abutments are placed and carefully

referenced. Separate lines are staked to establish the lines of the faces of wing walls, the lines of the parapets, faces of the haunches, and any special lines of control that are required. Considerable work and time may be saved by setting targets as well as hubs on the reference lines, the targets being set with sufficient stability to remain in place during the entire construction period. One or more bench marks are set at convenient points at the site. The locations of all stakes must be shown on a carefully drawn sketch in the notes. On large structures, two bench marks are established near the bridge site, one on each end of the bridge. When elevations are set for a structure, a check run must always be made back to a bench mark.

On large bridges where more accurate surveys are needed, additional care and measurements must be made to ensure the absolute integrity of the bridge layouts. To aid the Inspector in checking the details for construction of larger bridge structures, it is recommended that the more important control points, such as centerline of bearing and the base line station at centerline of bearing, be established on the structure as soon as the footing is completed. This will facilitate an accurate alignment and position check of the form panels as they are placed. Drill holes or concrete nails work well as point markers. If the elevations of these control points are accurately established, the inspectors will have a convenient datum to work from when checking form details.

Prior to starting a bridge in the field, the footing plan should be laid out to scale on paper, and the excavation payment line drawn on the plan. The Chief of Party uses this plan, which shows the location at each angle point and each change in width, to take the cross sections at the proper points. After the bridge is staked on the ground, the Chief of Party takes cross sections for bridge excavation. Sections are taken at each break in the payment line noted on the plan, as stated above, as well as at the breaks in the ground. The sections must cover any work required to widen or relocate the channel of a wet crossing.

### ***2-207G Staking Special Structures***

The staking of special structures is done well ahead of actual grading operations so that the contractor can do such work as building culverts, drains, sewers, and the line structures as early as possible to permit adequate settlement of the backfill. Ordinarily the inspector will be able to set construction stakes for culverts. The invert lines and grades for sewers, drains, large culverts, and other special structures are staked by the survey party on offset lines as agreed with the contractor. The stakes are set so that there is minimum of interference during the construction work.

### ***2-208 Replacing Stakes***

If stakes become lost, broken, or displaced, they are reset by the survey party that set them—the Department, consultant or contractor. If stakes that are set by Department forces are damaged, the Chief Inspector advises the Field Supervisor—Surveys or, if necessary, the Chief of Party in sufficient time so that the stakes can be replaced without delaying the construction work.

### ***2-209 Measurements for Monthly Estimates***

The survey party makes measurements of work, completed or in progress, needed by the Chief Inspector to prepare monthly estimates.

### ***2-210 Final Survey***

Checks on the contractor's ability to conform to the lines and grades given should be made during the course of the work by the appropriate inspector or survey party. Any deviations found should be brought to the contractor's attention,

through the Chief Inspector, so that corrections can be made as the work progresses. The more nearly the final project conforms to the original design the easier it will be to prepare the final quantities.

In general, any project or section of project that has been constructed in accordance with the designed plan will not require final cross sections. All ordered changes in line, grade or slope lines will have to be measured and the amount of the change added to or deducted from the original quantities. These changes should also be shown on the final plans and/or cross sections so that they are readily visible. Miscellaneous excavation for items such as driveways, drainage structures, and ramp approaches that are not covered by the original sections must be measured for payment. No cross sections will be required on pavements that have been constructed in conformance with "fine grades" established by the Engineer specifically to control pavement line and grade. The Inspector is responsible for ensuring that the pavement is built to these grades.

Rock sections are required at the time the rock is uncovered as well as when final measurements are taken.

On surplus excavation projects, it is not necessary to cross section the slopes of any fill. Slope stakes and occasional checks are sufficient to assure that the slopes are not appreciably less than designed.

On borrow projects, the amount of excess material placed outside the slope lines must be deducted from the borrow measurement. If the slopes are fairly uniform, taking a cross section to check the typical section is sufficient to determine whether the fill is constructed reasonably close to the design. If it is found that there are deviations that should be deducted from "Borrow," additional sections should be taken to accurately measure the deduction. Areas where the additional fill was directed by the Engineer, and therefore should not be deducted, do not require additional cross sectioning.