

# 12 Construction Surveys

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## 12 General

The Department is responsible for providing construction surveys to establish “control stakes”, also known as “grade stakes” for basic line and grade for project construction unless the contract specifies otherwise. From these control stakes the Contractor sets, when needed, supplemental “working stakes.” The control stakes are also used by the Resident Engineer (RE) or the Structure Representative to check the work for contract compliance.

This Chapter is to be used for all transportation improvement projects, including special funded projects. It shall be used by all Department employees or consultants performing construction surveys. It is their responsibility to adhere to all relevant processes, workflow, and provisions stated in this chapter.

This chapter provides policy, procedures and general information regarding Department-furnished construction stakes—the types of stakes furnished, and their density, placement, and markings. These procedures are subject to requirements in Contract specifications, Contract Change Orders (CCOs), or other provisions approved by the RE.

The *2010 Standard Specification* defines “Engineer” as “The Resident Engineer responsible for the Contract’s administration; the Resident Engineer’s authorized representative.” This chapter uses the terms Resident Engineer (RE) and Surveys. Surveys is the RE’s representative authorized to perform the construction surveys as described in this chapter.

## 12.1 Policy

The basic contract requirements regarding lines and grades, and construction stakes and marks, are included in the *Standard Specifications*. Additional contractual requirements might be shown on the plans or included in the special provisions for the work.

The Department's basic policy regarding Department-furnished construction stakes, as defined by this document and the *Standard Specifications*, is to provide the necessary control stakes to establish the lines and grades required for the completion of the work.

Working stakes used by the Contractor in actually performing the work are the Contractor's responsibility and are to be set by the Contractor's forces based on Department-furnished control stakes. Methods used to establish working stakes are at the Contractor's option. These methods may include any means capable of maintaining the necessary tolerances as required by the *Standard Specifications* and by the RE. Except for any contractual restrictions, the Contractor has the right to employ reasonable means and methods to prosecute the work on a project, including the use of Automated Machine Guidance (AMG) equipment.

The density of control stakes, as defined by this document, will not be increased. When conditions and tolerances for the type of work involved permit, fewer construction stakes will be set, as determined by the RE.

Examples are:

- a) only one set of control stakes describing the final grade may be set to complete a roadway involving minor grading;
- b) one set of stakes may be used for both final grade stakes and for curb stakes;
- c) existing pavement may be used to control contiguous widening work, instead of final grade stakes;
- d) Control stakes may be set at larger intervals when Automated Machine Guidance (AMG) is used.

Nothing contained in this chapter is to be construed to limit the surveyors' basic responsibilities related to land surveying work as contained in the Professional Land Surveyor's Act<sup>1</sup>.

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<sup>1</sup> Business & Professions Code Chapter 15, Sec. 8700-8805

### 12.1-1 Responsibilities

The responsibilities described in this section pertain to construction surveys. To be fully successful, all parties must act in concert. Each must cooperate to ensure a good working relationship.

Business and Professions Code section 8726(e) provides that a land surveyor has legal authority to:

"By the use of the principles of land surveying determines the position for any monument or reference point which marks a property line, boundary, or corner, or sets, resets, or replaces any monument or reference point."

All reference points necessary to allow the setting of control stakes will be set by Surveys. All monuments that mark a property line, boundary line, or corner must be set, replaced, or referenced under the responsible charge of a licensed land surveyor per section 8771 (b) of the Land Surveyor's Act.

Construction stakes must be set under the responsible charge of a licensed land surveyor or civil engineer. Stakes set that are referenced to California Coordinate System (CSS) coordinates must be set under the responsible charge a person authorized to practice land surveying in the State of California.<sup>2</sup>

#### 12.1-1(a) Surveys

Construction staking is the responsibility of Surveys. The construction surveys will be performed in cooperation with the Resident Engineer and the Structure Representative.

The following are the responsibilities of Surveys:

- a) Reviews site conditions for survey party safety.
- b) Ensures statewide conformity with this Chapter.
- c) Provides horizontal and vertical project control monuments and a project control diagram per Chapter 9 of this manual.
- d) Performs Department-furnished construction staking prior to contract award, as determined necessary by the RE.

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<sup>2</sup> Business & Professions Code Sec. 8726 (f) and (g)

- e) Begins staking within 2 business days of receipt of a completed Request for Construction Staking form from the RE.
- f) Attends the pre-construction meeting with the RE, Contractor, and Structure Representative to discuss project control, amount of construction stakes, and any AMG details before construction starts.
- g) Performs all Department-furnished construction staking that requires the use of a survey party.
- h) Determines the methods and procedures to accomplish the Department-furnished construction staking.
- i) Checks data furnished by the Project Engineer for completeness and discrepancies.
- j) Checks the conformity of planned lines and grades with existing conditions at pavement “conforms”, curb and gutter joins, inlets and outlets of drainage facilities, etc.; advises the RE of any problems; makes minor adjustments to lines and grades under the direction of the RE.
- k) Advises the RE of any discovered design issues regarding lines and grades, and records the issues in daily survey party reports.
- l) Keeps the RE informed of pertinent construction staking issues; accepts construction staking requests only from the RE; and keeps adequate records of Department-furnished construction staking efforts (work accomplished, dates, time and resources required, survey data and restaking).
- m) Preserves, references, or replaces all survey monuments according to Section 8771 of the Business and Professions Code.
- n) Verifies that all staking is clearly written and readily visible.
- o) Communicates with the Structure Representative on the availability of safety-related protection equipment for work on superstructures.
- p) When the Contractor is using AMG for construction, Surveys will:
- q) Verify survey control and provide the RE with coordinates and elevation for the local control calibration points to ensure datum consistency.
- r) Review the written calibration report provided by the Contractor using Global Navigation Satellite Systems (GNSS) technology. If the report is rejected, Surveys will confer with the RE and Contractor as soon as practical to resolve any problems.
- s) Set additional control to assist the RE staff in checking and inspection of project.

**12.1-1(b) Resident Engineer (RE)**

The Resident Engineer is responsible for the satisfactory administration and completion of the project, including the coordination of construction surveys in cooperation with Surveys and the Structure Representative. The RE will also ensure that Surveys is apprised of all project safety issues and that Surveys is notified in a timely manner of situations that would affect construction site survey operations.

The following are the responsibilities of the RE:

- a) At the preconstruction meeting or other times, explains to the Contractor with the assistance of Surveys (i) the Department-furnished construction staking procedures as detailed in this chapter; (ii) the procedures and contract requirements for requesting Department-furnished construction staking; (iii) the contract requirements regarding preservation of Department-furnished stakes, and (iv) staking furnished when AMG is used.
- b) Coordinates priorities and schedules for all requests for Department-furnished construction stakes.
- c) Verifies that the Contractor's requests for Department-furnished construction stakes are acceptable, including (i) the requested staking area is ready for stakes; (ii) the stakes will be used in a reasonable time period; and (iii) requests for "original" stakes are truly original.
- d) Works with the Project Engineer and Surveys to deliver needed electronic design files to the Contractor for use with AMG.
- e) Performs minor Department-furnished construction staking that does not warrant the use of a survey party (see section 12-5.14).
- f) Checks the final construction lines and grades against Department-furnished stakes to verify that the work was performed at the proper line and grade.
- g) Determines when restaking costs are to be assessed to the Contractor and coordinates with Surveys.
- h) Resolves design issues regarding lines and grades; and checks/approves line and grade adjustments made by Surveys.
- i) Settles disputes regarding staking priorities and schedules.

**12.1-1(c) Structure Representative**

The Structure Representative is responsible for the satisfactory completion of structures on a transportation improvement project. The Structure Representative will also ensure that Surveys is apprised of all Structures-specific project safety issues and that Surveys be apprised in a timely manner of situations that would affect construction survey operations for a structure.

The following are the responsibilities of the Structure Representative:

- a) Confers with Surveys regarding the need for Surveys support for the structures on a project and coordinates the assignment of resources for the requested support from Surveys.
- b) Coordinates with Surveys regarding any special job-specific safety training that may be required to perform a construction survey for a structure (i.e. fall protection, confined spaces, water safety, railroad safety training).
- c) Establishes with Surveys a communications protocol to be used for the life of the project when requesting Surveys support.
- d) Verifies that the Contractor's requests for Department-furnished construction stakes for structures are acceptable, including (i) the requested staking area is ready for stakes; (ii) the stakes will be used in a reasonable time period; and (iii) requests for "original" stakes are truly original.
- e) Interprets and translates all requests for construction stakes for a structure to stations and offsets that are referenced to a horizontal alignment shown on the contract plans.
- f) Recommends to the RE when the Contractor is to be assessed re-staking costs associated with structures.
- g) Establishes the priorities and schedules for requests for construction staking for structures with the RE and Surveys.

**12.1-1(d) Contractor**

The following are the responsibilities of the Contractor:

- a) Discusses scheduling of staking needs for Contractor operations and time estimates of staking operations with the RE and Surveys at the pre-construction conference and throughout the project.
- b) Requests Department-furnished construction stakes a minimum of 2 working days in advance of starting an operation that will use the stakes. Include estimated time to perform staking operations in addition to 2 working days notice when determining the start of specific construction operations.
- c) Submits a suitable Construction Survey Request (Form DPD-3013) for Department-furnished construction stakes, ensuring that the requested staking area is ready for stakes and that the stakes will begin to be used within 5 days of staking.
- d) Coordinates construction operations so that areas to receive stakes are relatively clear of construction equipment activity, in order that stakes can be set in a safe and expeditious manner.
- e) Establishes priorities for requested Department-furnished construction stakes and notes the priorities on the staking request.
- f) Submits all requests for Department-furnished construction stakes to the RE for approval.
- g) Preserves Department-furnished construction stakes, including those requested by the RE.
- h) Sets working stakes (i.e., “bluetops”) as required to complete the work.
- i) Reports suspect staking or design issues immediately to the RE.
- j) If using AMG, develops the needed electronic files and provides copies to Caltrans. If any design issues are discovered while creating the files, the RE will be notified promptly so a resolution can be determined.
- k) If using AMG, utilizes and constrains to the provided local survey control points.



**12.1-1(e) Project Engineer**

The Project Engineer will provide all files requested by Surveys as needed. The following information is a partial list of the typical delivery in the Survey File:

- a) Final reduced-size contract plans and annotated roadway cross-sections.
- b) Control diagram and coordinate list for the control used to design the project, if the survey control work was not performed by Department forces.
- c) All roadway alignments including main lines, ramps, branch connections, frontage roads, and detours.
- d) Roadway slope stake listings (one or two stations per page), for all roadway and detour alignments.
- e) Drainage cross-sections, alignments with station/offset and coordinates for angle points, end points, curve data, and structure locations with station/offset and coordinates to the centerline point at the flow line.
- f) All profiles including roadway, curb and gutter, ditch, and channel.
- g) All lay-out lines including ditches, channels, retaining walls, sound walls and benches, with station/offset and coordinates for angle points, end points and curve data.
- h) Taper, transition curve, superelevation diagrams, and flare locations, including sufficient data to precisely define beginning and ending locations and elevations, radius points, offsets, and parabolic curve base line distances.
- i) Data for structures including abutment and wing wall lay-out lines, abutment fills, and pier alignments.

**Note:** All design data will be delivered to Surveys in both digital and hardcopy format.

### 12.1-2 Requests for Construction Stakes

The *Standard Specifications* require the Contractor to provide a written request for Department-furnished construction stakes to the Resident Engineer. To facilitate the Contractor's written request and to ensure that all necessary information is included in the request, the RE will furnish the Contractor with a supply of Form DPD-3013, "Request for Construction Staking," for this use. See Figure 12-1. Requests for stakes will only be accepted by Surveys from the RE. The Contractor will submit an electronic version of Form DPD-3013 if requested by the RE.

Prior to contract award, requests for construction surveys originate in the Construction or Surveys branches. After contract award, most requests will be initiated by the Contractor. Exceptions include control surveys, monument staking, surveys for design information, and surveys to determine pay quantities.

When the Contractor requires construction stakes, the Contractor will notify the RE of his requirements, in writing, on form DPD-3013, in advance of starting operations that require the stakes. Surveys begins staking within 2 business days of receipt of a completed Request for Construction Staking form from the RE. Some requests for stakes will require more time to complete, thus requiring the Contractor to allow for staking time in addition to the 2 business days in advance of operations that will use the stakes. The Contractor, RE, and Surveys will discuss staking time estimates.

If the area or facility is not prepared satisfactorily for the stakes, as determined by the RE, the staking request will be voided by the RE and the Contractor must submit a new Request for Construction Staking form when the area or facility has been properly prepared. If a survey party has been mobilized to an area that is not ready for stakes, the RE may charge the Contractor with restaking charges for the survey party's time.

After receiving form DPD-3013 from the RE, Surveys schedules the work. To facilitate scheduling, requests will include calendar dates to indicate when the stakes are needed and all requests should be specific as to area and types of stakes to be set. If no priority number is listed on a staking request, staking will proceed in the order listed or received. If a request includes more stakes than the advance notice gives time to prepare for, it should be returned to the RE for a discussion on scheduling with the Contractor.

When staking is completed, the Party Chief will make his entries on form DPD-3013 and return the form to the RE. The Party Chief must notify the RE when a request for original stakes is actually for restaking.

**12.1-3 Request for Construction Staking Form DPD-3013**

All staking requests must be submitted on Form DPD-3013, or the equivalent information submitted by digital request.

**12.1-3(a) Contractor**

The Contractor will fill out the following sections of the form;

- a. Project information (if not pre-printed)
- b. Priority. If no priority is listed, the work will be performed in the order listed.
- c. Type of Staking. Slope Stakes, Curb stakes, Drainage, etc.
- d. Stakes are either Original or Reset
- e. Location. Alignment, beginning and ending stations, drainage structures, etc.
- f. Date. The Contractor will indicate the date that the site will be ready for stakes, and when the Contractor intends to begin work using the stakes.
- g. In the Comments section, Contractor will indicate requested offsets for the reference points, and any other relevant instructions.
- h. Contractor's signature and date of request

**12.1-3(b) Resident Engineer**

The RE will review the form as follows:

- a. Verify that the request date and date that the stakes will be used allow for the minimum two full working days for Surveys to complete the work.
- b. Verify that stakes listed as "Original" are not "Reset"
- c. Checks that the designated areas are ready for work.
- d. In consultation with Surveys (usually the Party Chief), determines that the staking request allows time for Surveys to complete the work in the time requested. If there is a scheduling issue, the RE will hold a meeting with the Contractor and Surveys to resolve the issue.
- e. If the RE determines that the request is not complete due to the failure to complete (a) through (c) above, the RE will return the request to the Contractor.
- f. When the RE determines that the request is acceptable, the RE will sign the form with date and time, and forward it to Surveys.

- g. If the request is for restaking, the RE will review the time actually charged by Surveys, calculate the costs, determine if the restaking costs are to be charged to the Contractor, and sign the determination.

#### **12.1-3(c) Party Chief**

The Party Chief will:

- a. Not perform any construction staking without a request signed by the RE, and approved by Surveys.
- b. Determine that the area is prepared for staking, and notify the RE if it is not.
- c. Set the construction stakes in the order and location requested, noting any changes on the field notes.
- d. Complete the “Party Chief” section of the form, indicating the date(s) that the staking was completed, and listing the total surveys crew hours needed to complete any reset stakes.
- e. When the entire request is completed, the Party chief will sign the form, and return it to the RE with a copy of the field notes for all work performed

#### **12.1-4 Restaking**

Section 5-1.26 of the 2010 *Standard Specifications* states that:

“Preserve stakes and marks placed by the Department. If the stakes or marks are destroyed, the Department replaces them at the Department’s earliest convenience and deducts the cost.”

Surveys will keep an accurate record of time required to complete restaking and report to the Resident Engineer and the Structure Representative any restaking that is done on form DPD-3013. The RE is responsible for determining if charges for restaking will be made and for establishing restaking priorities.

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**12.1-5 Alternatives to Normal Staking**

As determined by the Resident Engineer in cooperation with Surveys, additional Department-furnished construction stakes will be provided for areas of staged construction, as necessary, to provide control for the lines and grades (see Section 12.5-6, “Final Grade Stakes, Staged Construction”).

Department-furnished construction stakes will be provided for facilities not covered by this document to control lines and grades, as determined necessary by the RE and the Structure Representative in cooperation with Surveys.

In cooperation with the RE, the Structure Representative, and the Contractor, alternate Department-furnished construction stakes (stake density, placement, and markings) will be considered to facilitate the Contractor’s construction methods, providing such stakes do not require more Department surveying resources than the stakes outlined in this document.

For reconstruction and rehabilitation work, other Department-furnished construction stakes might be requested when the stakes described by this document are impractical, as determined by Surveys. For example, reference marks with a stationing identification might be painted on existing pavement and a hardcopy listing provided to the Contractor of elevations, distances, or cuts/fills as appropriate.

### 12.1-6 Automated Machine Guidance (AMG)

Automated Machine Guidance (AMG) technology uses positioning devices, alone or in combination, such as the Global Navigation Satellite System (GNSS), Total Stations, and/or rotating laser levels to determine the real time X, Y, and Z position of construction equipment and compare that position against a 3D Digital Design Model (DDM) stored in an onboard computer. A computer display shows the operator or grade checker several perspectives and delta values of their position compared to the design surface. This technology has the potential to increase the Contractor's efficiency, increase the Contractor's productivity, reduce the number of survey stakes required, and reduce construction working days. The construction industry is currently implementing AMG and the Department has developed interim guidelines to foster its use:

[http://www.dot.ca.gov/hq/row/landsurveys/SurveysManual/AutomatedMachineGuidanceGuidelines7\\_5\\_09.pdf](http://www.dot.ca.gov/hq/row/landsurveys/SurveysManual/AutomatedMachineGuidanceGuidelines7_5_09.pdf)

AMG information is a guideline only, and subject to change at any time.

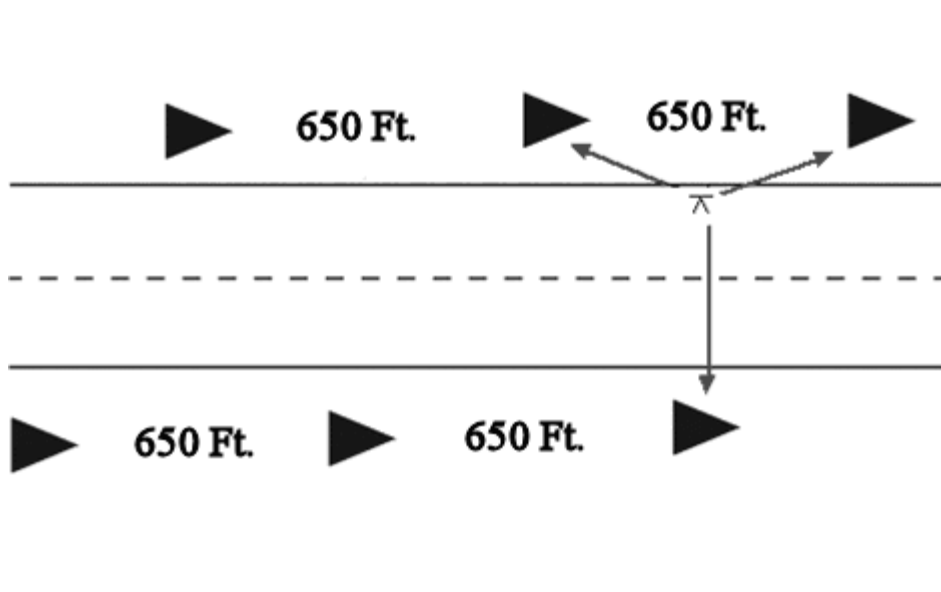
#### 12.1-6(a) Supplemental Project Control

AMG may require a higher density of control monuments than needed for conventional methods. Setting additional monuments for machine guidance is part of construction staking. The Contractor must utilize and constrain to the provided project survey control points for the Digital Terrain Model (DTM), DDM, and construction equipment locations to match.

GNSS satellite signals can be subject to interference from canyons, buildings, trees or even fencing. Additional monuments will be set when needed for adequate site coverage. Not all locations are suitable for AMG techniques, and it is the Contractor's responsibility to determine if the site conditions are practical for AMG.

Robotic total station guided equipment, such as paving machines, require a more dense survey control network of a higher order of vertical accuracy than GNSS controlled systems (see Figure 12-2).

Below is a diagram showing a typical control scheme where the total station position is set up at random and the coordinates are established using a resection solution. Control is staggered on either side of the highway to provide a good strength of figure. While the distance between control points shown here is no farther than 650 ft., the actual distance varies by the type of equipment used by the Contractor. The vertical accuracy of the control must be such that the total station elevation can be established with an accuracy of  $\pm 0.01$  ft.



**Figure 12-2**

Surveys involvement in projects using AMG technology can vary from project to project, but in general may include the following:

- a) Provide the Project Engineer with 3D files of the existing ground surface and review the DDM and Survey file developed by the Project Engineer.
- b) Report any issues to the Project Engineer and the RE.
- c) Assist the Project Engineer with data format conversion as expertise permits.
- d) Recover, verify, and evaluate project survey control used to develop the existing ground surface for consistency and create a site calibration prior to construction.
- e) Perform terrain checks to identify any changes from earlier mapping.
- f) Establish supplemental project control as needed for AMG operations.



- g) Meet with the RE and the Contractor to discuss control, calibration, and staking.
- h) Provide the Contractor with the latest control points. Provide the RE and Contractor with coordinates and elevation for the local survey control calibration points to ensure project consistency.
- i) Review the Contractor's calibration report and compare with the Department's calibration.
- j) Assist the RE with inspection of line and grade in areas without conventional staking. Surveys may assist the RE with project inspection using survey equipment, the project model, and survey control if so resourced and requested.
- k) Surveys will set additional control to assist the RE staff in checking and inspection of project.
- l) Deliver the files necessary to the RE in order for the RE to evaluate work completed by AMG methods.
- m) Act as an advisor to the RE as requested on GNSS and AMG issues.

**Suggested Best practices for Surveys include:**

Set conventional slope stakes at all “conform” stations, beginning and end of curves, and begin and end of transitions to aid with inspections. Set stakes as requested by the RE for inspection purposes.

Set other construction stakes as necessary. The use of AMG will not eliminate the need for the staking of structures, drainage, utilities, etc.

## **12.2 Research and Office Preparation**

### **12.2-1 Research**

Construction surveys generally require minimal research efforts. Research of Survey's files may be required for the retrieval of vertical and horizontal project data that will be used in the planning and setting of supplemental construction control. This includes the use of the Project Control Map described in Chapter 9 of this manual and Chapter 2 of the Plans Preparation Manual. If land net monumentation will be disturbed by construction, then research and planning for land net field ties, monumentation renewal, corner restoration, and perpetuation of monuments and lines must be undertaken per Chapter 11 of this manual.

### **12.2-2 Office Preparation**

Surveys is responsible for confirming that data obtained from the Project Engineer (see Section 12.1-1, "Responsibilities") is both complete and suitable. Missing data, conflicts and uncertainties must be reported to the Project Engineer and/or the Resident Engineer as appropriate. Surveys should not revise design data without the approval of the Project Engineer and/or the RE.

Surveys should develop a strong partnership with the Project Engineer to ensure that the information outlined in Section 12-1.1 is provided in a ready-to-use format. Duplication of efforts by the Project Engineer and Surveys must be avoided.

Whenever practical, the Surveys office prepares the information for staking, called the staking package. The staking package should include all information required to efficiently stake the project. Generally, a construction survey effort should not begin without a completed staking package produced in an office environment where efficient, appropriate data processing capability is available. Use of survey party time to prepare the package should be minimized.

### 12.2-3 Preconstruction Conferences

**Resident Engineer/Surveys:** Surveys will have a preconstruction meeting with the RE. Any Party Chief(s) permanently assigned to a project should attend this meeting. This meeting should occur soon after the RE is assigned. The purpose of this meeting is to establish a working relationship between the RE and Surveys and to review the anticipated survey work, including tentative schedules and project-specific safety issues. Anticipated survey requests prior to contract award should also be discussed.

**Resident Engineer/Contractor:** Surveys should attend the pre-construction meeting between the RE and the Contractor. Surveys should provide the Contractor with a copy of this chapter of the Surveys Manual and explain that, along with the *Standard Specifications*, it represents the Department's procedures concerning Department-furnished construction stakes. Surveys should be ready to describe the types, density, placement and marking of stakes, and explain the construction staking request process, including the Contractor's responsibilities of coordinating construction operations so that areas to receive stakes are relatively clear of construction equipment activity, in order that stakes can be set in a safe and expeditious manner. Calibration and control issues must be discussed on AMG projects. The need for preserving stakes and the restaking process should also be discussed.

**Structure Representative/Surveys:** Surveys will have a preconstruction meeting with the Structure Representative on projects that have structures. This meeting should occur soon after the Structure Representative is assigned. The purpose of this meeting is to establish a working relationship between the Structure Representative and Surveys and to review the anticipated survey work, including tentative schedules. Anticipated survey requests prior to contract award should also be discussed. This meeting may occur in conjunction with the Preconstruction Conference between the RE and Surveys.

## 12.3 Stake Tolerances

### 12.3-1 Tolerances

Tolerances stated for each type of control stake in this chapter indicates the acceptable deviation of the position of each reference point from its computed position *relative to the given alignment and grade*. When the stake is positioned within its tolerances, it is deemed “good.” Staked positions are generally checked using electronic stakeout reports and, if within tolerances, the staked position is accepted. For precise measurements such as structures, reference points may also have an accuracy relative to each other.

The head of a nominal 1”x1” wooden ginnie is 0.06’ square. A point set to a tolerance of 0.03’ will fall on the head of the ginnie, and is considered within tolerance. The same is true for most metal spikes. If larger ground stakes are used (see Sec. 12-4), tacks or punch marks will be set to achieve the required tolerance for a given reference point.

Tolerances should not be confused with accuracy standards. Accuracy is a function of the random errors associated with the survey methods and procedures that are used for the whole survey project, including project control, construction control, and construction survey set-up points. For construction surveys, survey accuracy standards indicate the expected variation in position based on random errors *for the set-up points*, not variation in the construction stakes themselves.

### 12.3-2 Checking

Sufficient independent field checks must be made at the discretion of the Party Chief to assure the integrity of the control stakes. The integrity of radial stakeout set-up points should be verified before use by making check measurements from other control points and chaining between set points. All positions staked in the field should be checked against the computed positions and the results recorded in electronic stakeout reports and/or on stakeout listings, such as slope stake listings that are provided by the Project Engineer.

### 12.3-3 Field Notes

Construction survey field notes in the form of electronic stakeout reports, stakeout listings with actual staked positions noted, or other suitable forms, will be filed with the Resident Engineer upon completion of the survey. The RE will provide copies to the Contractor upon request.

## 12.4 Stake Types and Markings

The stake marking format shown in this Chapter is used when marks are placed on the Department's standard plastic marking cards which are attached to marker stakes. If the markings are placed directly on wood stakes, the Party Chief may revise the marking format for grading stakes (slope stakes, final grade stakes, etc.) and curb stakes as follows:

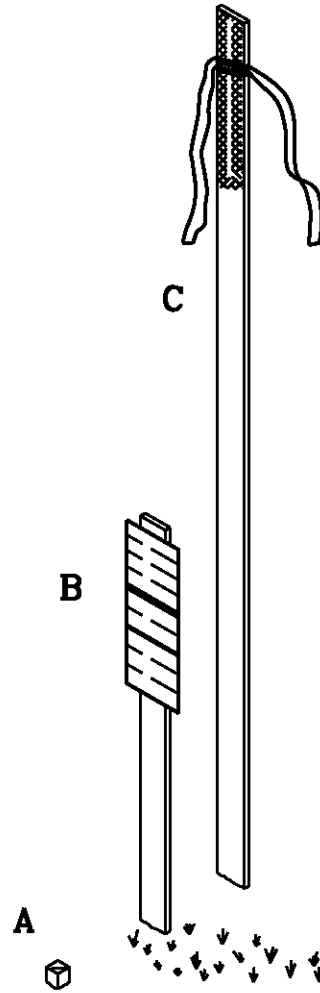
Alignment Name and Station – back of stake

Elevation – back or side of stake

Distances and cuts/fills are measured from the reference point for the stake to the point (feature) being staked (referenced, located). For most staking, the reference point for measurements is the ground stake. The elevation markings are for the top of the reference point. Examples of ground stakes are (a) small wooden hub (ginnie) in front of the marker/reference stake, (b) a wooden hub and tack in front of the marker/reference stake, (c) a spike driven in front of the marker stake, (d) a concrete nail in AC pavement (e) a scribed "X" on PCC pavement, or (f) the marker stake itself, depending on the precision required and field conditions (typically for fencing and clearing limits).

48" lath with flagging are used only when extra visibility is needed, typically when stakes are in tall vegetation, or as guard stakes to protect survey control monuments and marker stakes. See Figure 12-3.

- A. Reference Point or Ground Stake  
Distances and elevations are referenced from this point  
1"x1" wood "Ginnie" shown in Fig. 12-3
- B. Marker (Reference) Stake  
Lath with attached Marker Card shown
- C. 48" Lath with paint and flagging  
Used as guard stake for a Marker Stake when needed for extra visibility, or can be used alone (with or w/out ground stake) for clearing limits and fencing.



**Figure 12-3**

Distances are measured from the reference point in a direction away from the face (front) of the marker stake. The face is the side of the stake which shows the references (e.g., distance) to the point being staked (referenced).

Superelevation grades (pavement cross-slopes) are marked as percentages (vertical rise or fall, in feet, per 100 feet horizontal distance). The superelevation slope direction marking (plus or minus) is *determined on a normal or radial line FROM the STATIONING LINE "OUT"* (right or left), regardless of the location of the stake.

Slope ratios are marked as horizontal distance to vertical distance (e.g. 2:1) for projects dimensioned in feet. The direction of the slope (plus or minus) is not given.

When an elevation is shown on the plans for a point to be staked, stake markings will show only the reference point elevation, not a cut or fill to the point being referenced. Exceptions are if the planned lines or grades are adjusted to conform to existing conditions, or for other reasons as directed by the RE.

The RE must be immediately advised of any discrepancies between the plans and the stake markings; e.g., a cut or fill marked on a stake does not agree with that determined from the plans and the ground stake elevation. (Note: Some discrepancies might occur because of required field adjustments.)

### 12.4-1 Reference Stake Marking Format

The markings at the top of the stake provide information about the given stake (its identification, location, etc.). The “a”, “b”, etc. listed below, and in the sections that follow, refer to the example stake marking notations.

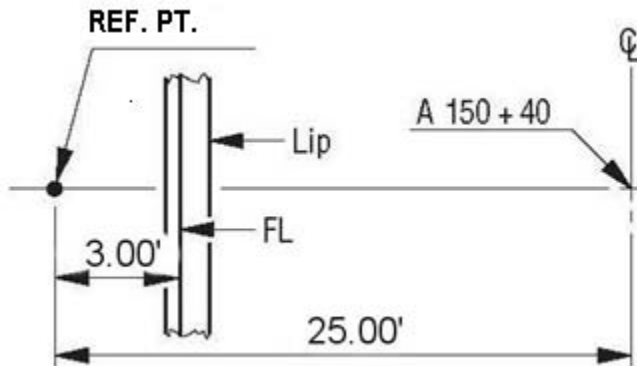


Figure 12-4

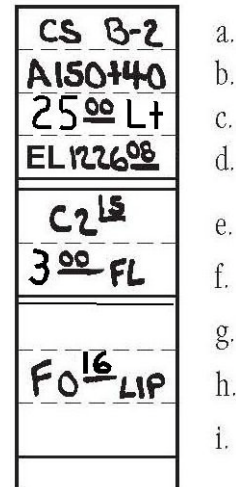


Figure 12-4A

- a. Feature being staked (referenced, located); e.g., slope, final grade, sign foundation, abutment, etc.
- b. The alignment and station are defined by the reference stakes (reference point, marker stake and line stake). Reference stakes are set on a line normal or radial to the stationing line at the specified station. On the example shown, the horizontal alignment is the “A” line, and the station is 150+40.  
Note: Stations are 100 foot intervals.
- c. Distance left or right normal or radial from the reference point to the stationing line identified in the marking above, along the specified cross-section. If no offset distance is given, the reference stakes are set on the line, and the CL symbol is used.
- d. Elevation of the reference point.

The next set of markings provides information about the point (feature) that is being staked (referenced, located).

- e. Cut or fill from the reference point to the point that is being staked. If elevations are shown on the plans, cuts or fills are not provided unless field adjustments are made.
- f. Distance from the reference point to the point and the line being staked. Note: Generally, this line intersects either perpendicularly or radially the line defined by the stake pair (see stake marking “b”).



g. –i. Additional markings follow, below marking “f”, as required providing the necessary control information for establishing other lines and grades.

Distances, elevations, and cuts/fills should be marked to the nearest hundredth of a foot (0.01’) for all references except for slope stakes, abutment fill stakes, and rough grade stakes, all of which should be marked to the nearest tenth of a foot (0.1 foot).

#### 12.4-1(a) Stake Marking Directly on Lath

The stake marking described above is best when using Department-furnishing marking cards. For marking directly on wooden lath or stakes, Figure 12-4B is acceptable.

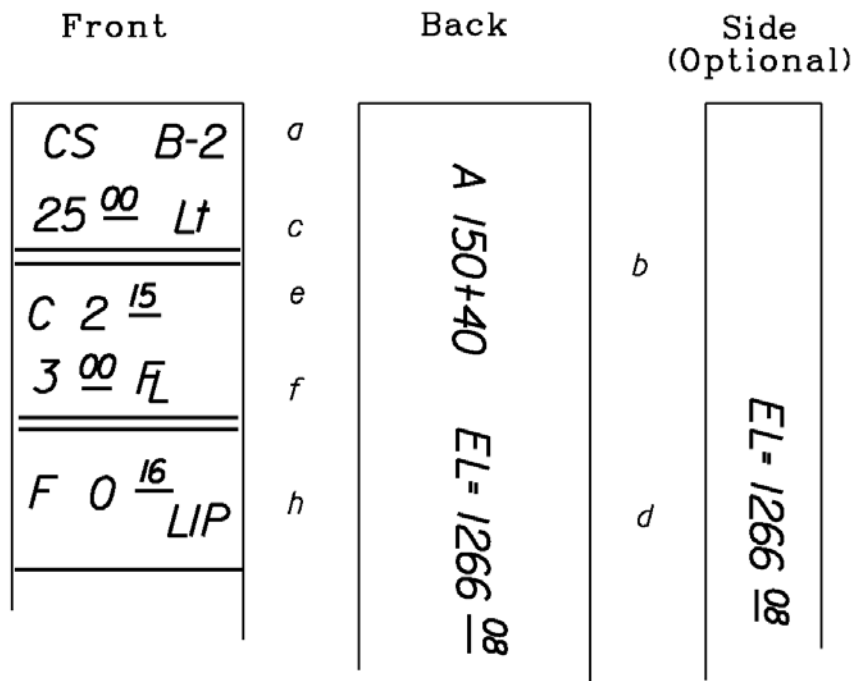


Figure 12-4B

**12.4-2 Control Stake Color Code**

Stakes are color coded to conform with the following table.

<b>Type of Stake</b>	<b>Description</b>	<b>Color*</b>
Horizontal Control	Coordinated control points, survey monuments, centerline alignments, etc.	White/Red
Vertical Control	Bench marks	White/Red
Clearing	Clearing limits that don't coincide with Right-of-Way lines.	Yellow/Black
Grading	Slope, intermediate slope, abutment fill, rough grade, contour grading, final grade, etc.	Yellow
Structure	Bridges, sound and retaining walls, box culverts, building foundations, etc.	White
Drainage	Pipe culverts, drop inlets, headwalls, curbs, gutters, sewer, etc.	Blue
Right-of-Way	Fences, R/W lines, easements, property monuments, etc.	White/Yellow
Miscellaneous	Signs, railings, barriers, lighting, etc.	Orange

\* Flagging and marking cards, if used.

Stakes are not always visible due to a lack of contrast with their surroundings. When this happens, contrasting flagging such as pink, white, or orange can be added to increase visibility.

### 12.4-3 Control Stake Marking Abbreviations

Commonly used stake marking abbreviations are listed below. This is not a complete list of all marking abbreviations. See CADD Manual Chapter 3.6 and Standard Plan A10 for additional abbreviations.

<b>Δ/2</b>	one-half curve length. Used for cul-de-sacs and curb returns. Δ/4, etc.	<b>DI</b>	Drainage inlet
<b>20B</b>	Example of sign identification number.	<b>DIT</b>	Ditch
<b>34-a</b>	Example of number of a drainage facility (system and unit).	<b>DS</b>	Drainage stake or system
<b>ABUT</b>	Abutment	<b>EC</b>	End curve
<b>AHD</b>	Ahead	<b>ECR</b>	End of curb return
<b>B-2</b>	Example of a type of curb.	<b>EL</b>	Elevation
<b>BAR</b>	Barrier (face) if coincident with ES, Use BAR	<b>ELEV</b>	Elevation
<b>BC</b>	Begin curve	<b>END</b>	End or ending
<b>BEN</b>	Bench	<b>EP</b>	Edge pavement
<b>BCR</b>	Begin curb return	<b>ES</b>	Edge shoulder
<b>BEG</b>	Begin or beginning	<b>ESR</b>	End of slope rounding
<b>BSR</b>	Begin slope rounding	<b>ETW</b>	Edge traveled way
<b>BL</b>	Base line	<b>EW</b>	End wall
<b>BK</b>	Back, use with other such as WALL, or SW	<b>F</b>	Fill
<b>BR</b>	Bridge	<b>FDN</b>	Foundation
<b>BSW</b>	Back of sidewalk	<b>FNC</b>	Fence
<b>C</b>	Cut	<b>FG</b>	Finish grade
<b>CGS</b>	Contour Grade Stake	<b>FGS</b>	Final grade stake
<b>CHNL</b>	Channel	<b>FL</b>	Flow line, also $F_L$
<b>CL</b>	Centerline, also $\mathcal{C}$	<b>FLC</b>	Flow line curb
<b>CONFM</b>	Conform	<b>FSW</b>	Front of sidewalk
<b>CONT</b>	Contour	<b>FWALL</b>	Face of wall
<b>CNTRL</b>	Control Stakes	<b>GRT</b>	Grate
<b>CP</b>	Catch point	<b>GTR</b>	Gutter
<b>CS</b>	Curb stake	<b>HP</b>	Hinge point – top of slopes within the design surface
<b>DAY</b>	Daylight; point/line of change from cut to fill or fill to cut or end cut/fill	<b>ISS</b>	Intermediate slope stake
<b>D/L</b>	Daylight; see above	<b>INV</b>	Invert
		<b>L</b>	Length

<b>L/2</b>	The mid-point of a longitudinal facility. Most often used for drainage stakes.	<b>RP</b>	Reference point; the stake, mark, or point is a reference to another specific point.
<b>L/4</b>	Same as L/2, except for a quarter-point.	<b>RP</b>	The point from which references such as cuts/fills, distances, and elevations are made.
<b>LIP</b>	Lip of a feature, such as the lip of a gutter.	<b>RPSS</b>	Reference point for a slope stake; the reference point (stake) is not the actual slope stake point, but a reference to the staked point (CP, ESR, etc.).
<b>L/O</b>	Line only; Reference point is good for line only, not distance; if elevation is given, the reference point is good for elevation.	<b>RSP</b>	Rock Slope Protection
<b>LOL</b>	Lay-out line for retaining, sound, or wing walls	<b>RT</b>	Right
<b>LT</b>	Left	<b>R/W</b>	Right of way
<b>ML</b>	Match line (grade break)	<b>S/C</b>	Saw cut line
<b>MON</b>	Survey Monument	<b>SE</b>	Superelevation
<b>MSR</b>	Mid-point of slope rounding.	<b>SG</b>	Sub grade
<b>OG</b>	Original ground	<b>SHLD</b> or <b>SHO</b>	Shoulder
<b>O/S</b>	Offset	<b>SL</b>	Stationing line
<b>PCC</b>	Point of compound curve	<b>SR</b>	Slope rounding
<b>PG</b>	Profile grade	<b>SS</b>	Slope stake
<b>PPP</b>	Pavement plane projected. The plane of the traveled way projected to a specified point (also SL).	<b>STR</b>	Structure
<b>PRC</b>	Point of reverse curve	<b>SW</b>	Sidewalk
<b>QSR</b>	Quarter-point of slope rounding.	<b>TBC</b>	Top back of curb
<b>1/4 SR</b>	Quarter-point of slope rounding; 1/4 the distance from the beginning.	<b>TBERM</b>	Top of Berm
<b>1/2 SR</b>	Mid-point of slope rounding.	<b>TC</b>	Top of curb
<b>3/4 SR</b>	3/4-point of slope rounding; 3/4 the distance from the beginning.	<b>TDITCH</b>	Top of Ditch
<b>R</b>	Radius	<b>TOE</b>	Toe; e.g., toe of a fill
<b>RGS</b>	Rough grade stake	<b>TOP</b>	Top; e.g., top of a feature, such as berm, ditch, or wall.
		<b>TW</b>	Travelled Way
		<b>WALL</b>	Wall
		<b>WW</b>	Wingwall

## 12.5 Typical Department-Furnished Construction Stakes

This Chapter outlines the typical types, density, and placement of Department-furnished construction stakes.

Alternate locations (positions) for the Department-furnished stakes may be used if required by the construction conditions, as determined by Surveys. See example shown for Drainage Stakes.

### 12.5-1 Clearing Stakes

Clearing Stakes are set to show the limits of clearing and grubbing. Generally, the plan limits are those specified by Section 16 of the *Standard Specifications*, “Clearing and Grubbing.” Clearing Stakes are only set when the limits are not defined by the contract. Clearing stakes are set for: Clearing-only contracts, contracts requiring clearing to be completed for new aerial photography/ remote sensing before grading, and where necessary as determined by the RE in cooperation with Surveys to protect and preserve desirable natural features.

**Stake Set:** Lath at clearing limit, no reference point, see Figure 12-5.

**Color Code:** Yellow/black.

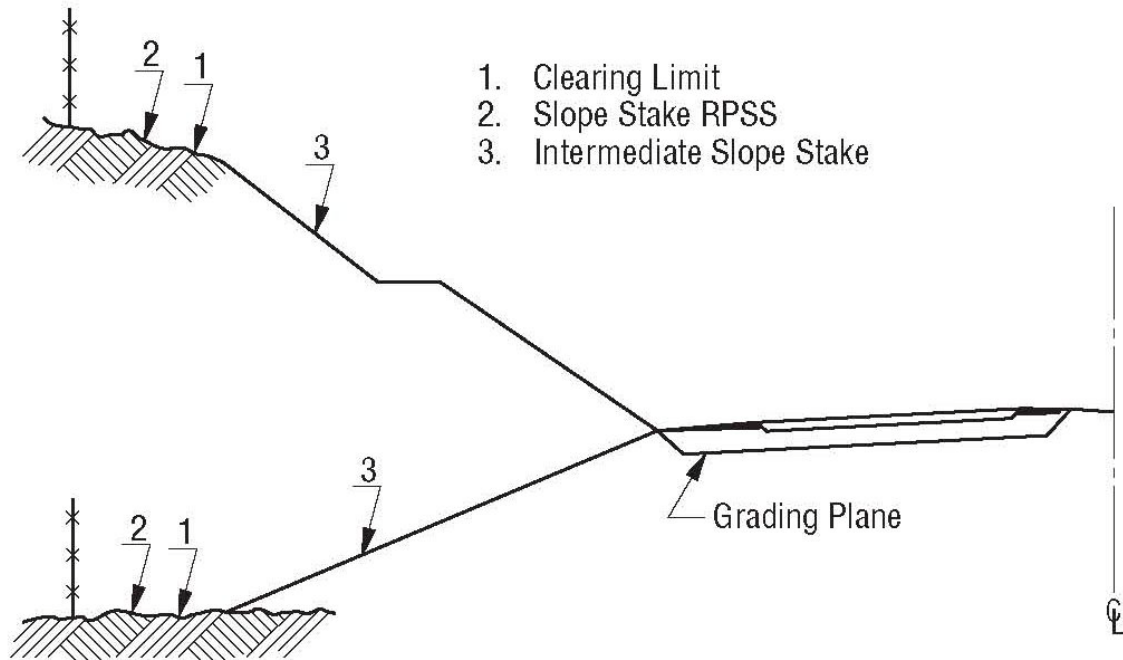
**Spacing:** Space longitudinally as necessary to provide intervisibility, but not less than 100 feet.

**Markings:** Mark “CLEAR LIMIT” on the lath facing the centerline.

**Setting Tolerance:** Stakes should be set within 1.0 foot of planned clearing limit.

Consider using a greater accuracy in park lands, areas where the entire right-of-way is to be cleared like orchards or urban areas, and where there is possibility of damage to highway facilities or utilities.

**Checking:** Check stakes visually and by reviewing the electronic stakeout reports and/or survey notes.

**Figure 12-5****12.5-2 Slope Stakes**

Slope stakes are set to control the construction of earthwork slopes. They are set to mark the designed intersection of a constructed slope and original ground or the “catch point.” Stakes are not set at the catch points, but elevations of design positions for catch points should be checked in the field. Instead, reference points (RPSS) are set at a constant offset distance from the catch point, generally 10 to 20 feet. See Figure 12-6. In some cases, one set of stakes may be used for several purposes, such as slopes, final grades and curbs. See Section 12.1, “Policy.”

**Stake Set:** Reference point with marker stake and, if required, a line stake at a convenient distance, generally greater than 10 feet, from the reference point. Line stakes are set in areas where visual lines, normal or radial to the station line, cannot be established as in the case when staking ramps, where the one side that is staked is not normal to the mainline. Refer to “Markings” for information regarding staking of slope rounding.

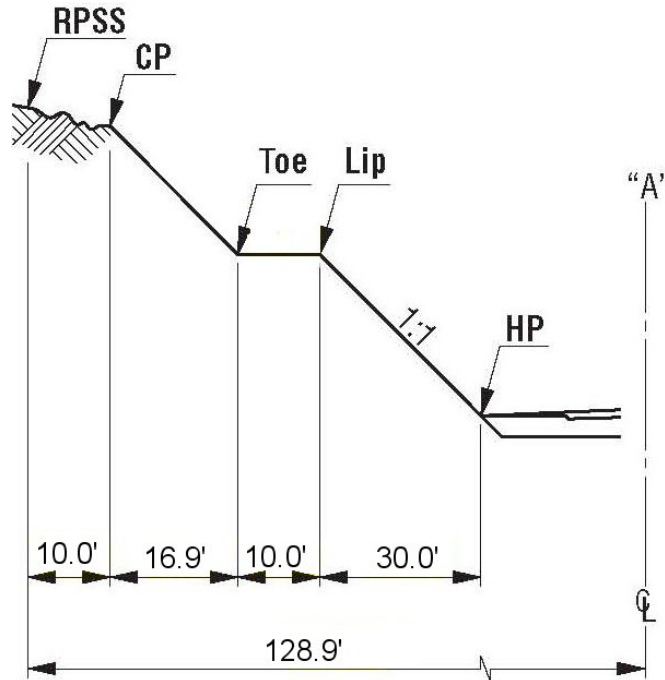


Figure 12-6

RPSS	a.
A 50+40	b.
128.9' L+	c.
EL 406.2	d.
-0.6	e.
10.0' CP	f.
C 16.9	g.
16.9' BCH TOE	h.
1:1	i.
F 1.0	j.
10.0' BCH LIP	k.
10:1	l.
C 30.0	m.
30.0' HP	n.
1:1	o.

Figure 12-6A

Generally, the actual slope stake catch point is not staked in the field. Instead, locations determined from the plans and cross-section information are used. Thus, the slope stake point as staked *might not be actually on the ground surface*; it might be above or below the ground surface (see “Checking,” below). In these cases, it is the Contractor’s responsibility to determine the actual ground location of the slope stake point as necessary.

Consistent differences in catch point elevations must be reported to the RE. The Party Chief will also determine if the revised staking conflicts with the right of way or any easement lines.

**Color Code:** Yellow.

**Spacing:** Space longitudinally every 100 feet. Decrease spacing to 50 feet when necessary for intervisibility of stakes, on curves of less than 1000 foot radius, or when cuts/fills are in excess of 10 feet.

**Markings:** The following list refers to the example stake marking Figure 12-6A.

- a. “RPSS” identifies the stake as a reference point to the slope stake point (catch point or end of slope rounding); in Figure 12-6A, the catch point.
- b-d. These markings follow the general stake marking format (see Section 12.4-1, “Reference Stake Marking Format”). In Figure 12-6A, the reference point for the “RPSS” is on the “A” 50+40 cross-section, 128.9 feet left of the “A” stationing line. The RP elevation is 406.9 ft.
- e-f. The plus or minus in elevation and the distance from the “RPSS” reference point to the actual slope stake point. Marking “f” also identifies the kind of slope stake point that is being referenced. In Figure 12-6A, the slope stake point is a catch point, and it is 0.6 feet below and 10 feet towards the “A” stationing line from the reference point.
- g-o. Each set of markings shows the cut or fill and distance from the slope point defined by the previous set of markings to the next slope point, and identifies the kind of grading point (line) that is being referenced. The cuts/fills and distances are NOT from the “RPSS” reference point, and ONLY the FIRST set of markings is from the slope stake point. This is sometimes called “point to point” or “then” slope staking.

Each set of markings consists of three markings—cut/fill, distance, and slope ratio. The distance marking also identifies the kind of grading point (line) that is being referenced.

**First Set of Markings:** From the catch point, there is a cut of 16.9 feet on a 1:1 slope (16.9 feet horizontally) to the toe at the bench.

**Second Set of Markings:** From the bench toe (not from the catch point), there is a 1.0 foot fill on a 10:1 slope (10.0 feet horizontally) to the lip of the bench (the lip is 1.0 foot above the bench toe).

**Third Set of Markings:** From the lip of the bench, there is a cut of 30.0 feet on a 1:1 slope (30.0 feet horizontally) to the hinge point.



**Slope Rounding Stake Markings:** If staked, slope rounding points are referenced in the same manner as other slope points, as outlined above; i.e., point to point. The need for slope rounding stake markings will be determined by the Surveys personnel in cooperation with the RE. General slope rounding staking (stake marking) guidelines, based on the slope rounding length, are as follows:

*Length 20 feet or Less:* No slope rounding references provided. It is the responsibility of the Contractor to construct the slope rounding as shown on the plans.

*Length Over 20 feet to 40 feet:* Beginning, mid-point, and ending (the slope stake point) are referenced.

*Length Over 40 feet to 90 feet:* Beginning, quarter points, mid-point, and ending (the slope stake point) are referenced.

*Length Greater than 90 feet:* Slope rounding points are referenced at a 30 foot interval.

**Setting Tolerance:** RPSS stakes should be set within 1.0 foot for stationing, 0.1 foot for offset distance and 0.1 foot for elevation for cuts or fills less than 10 feet. RPSS stakes should be set within 1.0 foot for stationing, 0.2 foot for offset distance and 0.2 foot for elevation for cuts or fills of 10 feet or greater.

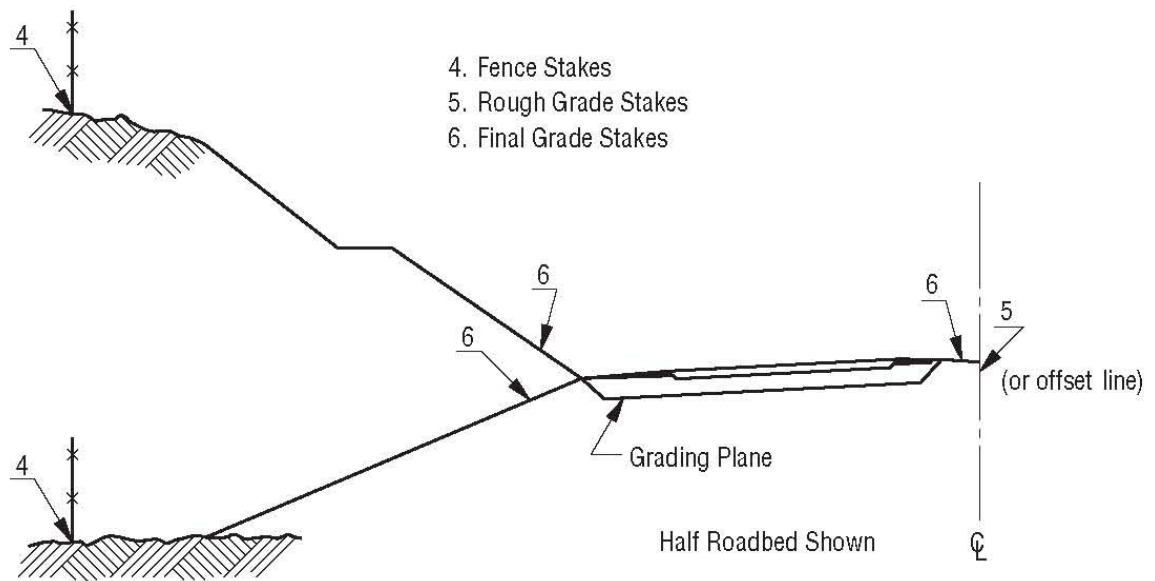
**Checking:** Check stakes visually and by reviewing the electronic stakeout reports and/or survey notes. Catch points should be checked against the design positions. If the vertical difference between design position and the ground is over 0.5 feet, the catch point should be located on the ground and a reference point set and marked reflecting the ground location of the catch point. All significant or consistent changes in catch point position should be reported to the RE.

### 12.5-3 Intermediate Slope Stakes

As determined by the RE in cooperation with Surveys, intermediate slope stakes are only set when necessary with station spacing of 50 feet to control cut-slope benches, fill-slope struts, and slopes in very heavy grading (cuts or fills in excess of 30 feet). For additional staking standards see Section 12.5-2, "Slope Stakes" and Figure 12-5.

### 12.5-4 Fence Stakes

Fence stakes are set to construct fences for highways with restricted access and for adjoining property owners when required by right of way (R/W) acquisition contracts. Department R/W fencing for restricted access facilities is constructed within the R/W. Fencing for other highways are constructed on the adjoiner's property. Fences are generally built 0.5 foot from the Right-of-Way line or Access Control line. See *Standard Plans* A85 and A86 and Figures 12-7 and 12-7A.



**Figure 12-7**

## Details from Standard Plans A-86

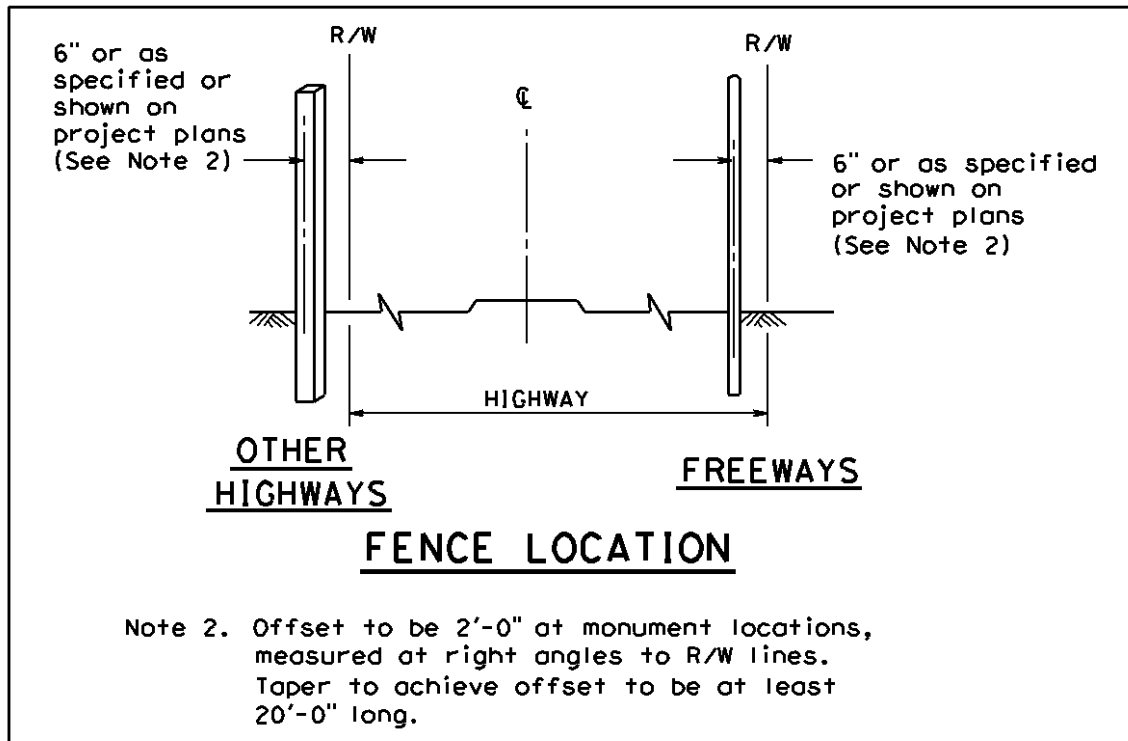


Figure 12-7A

**Stake Set:** Reference point and marker stake, or marker stake only on the R/W line or Access Control line (typ. between freeway and frontage road). For fencing that is not controlled by the R/W line, stake actual fence line or offset as requested. (see Standard Plans A85 and A86).

**Color Code:** White/yellow

**Spacing:** All stakes should be intervisible with the adjoining stakes. Place at all fencing angle points and beginnings and ends of curves. Space stakes longitudinally every 200 feet on tangents, 50 feet on curves with a radius of 1000 feet or more, and 25 feet on curves with radius of less than 1000 feet.

**Marking:** For Right of Way fencing, stake the R/W line and label it "R/W". When the fence line isn't along the R/W line, the actual fence line is staked and should be marked "Fence".

**Setting Tolerance:** Stakes for fencing should be set within 0.1 foot horizontally of R/W or fence alignment. No elevations needed.

**Checking:** Check stakes visually and by reviewing the electronic stakeout reports and/or survey notes.

### 12.5-5 Rough Grade Stakes

Rough grade stakes are set to aid rough finishing of the grading plane. They are set when requested by the RE when cuts or fills are greater than 30 feet. Intermediate slope stakes will serve as rough grade stakes if within 30 feet (cut/ fill) of the grading plane. See Figure 12-7. The RE should discuss the need for rough grade stakes with the Contractor using AMG prior to construction.

**Stakes Set:** Reference point with a marker stake on only one line per roadbed, such as the centerline of construction.

**Color Code:** Yellow.

**Spacing:** Space longitudinally every 50 to 100 feet, as determined by Surveys with the concurrence of the RE, depending on the construction conditions, alignment and grade.

**Markings:** Stakes should be marked “RGS” for rough grade stake and identify the line and station and off-set, if any, on which they are set, and give the cut/fill to finished grade for the point the stake references.

**Setting Tolerance:** Stakes should be set within 1.0 foot for stationing, 0.1 foot for horizontal offset, and 0.1 foot vertically of calculated position.

**Checking:** Check stakes visually and by reviewing the electronic stakeout reports and/or survey notes.

### 12.5-6 Final Grade Stakes

Final grade stakes are set when the rough finishing of the grading plane is completed. Department-furnished final grade stakes are set only once for each grading plane. This one set of final grade stakes controls all elements of the structural section (the grading plane, subbase, base, and pavement). See Figures 12-8. In some cases, one set of stakes may be used for several purposes, such as slopes, final grades and curbs. See Section 12.1, “Policy.”

**Staged Construction:** The RE, in cooperation with Surveys determines stakes needed for staged construction. A common form of staged construction is widening of existing pavement. Generally, the longitudinal spacing for this type of staged construction is the

same as conventional construction, but the types of stakes and markings used will depend on conditions found on specific projects. See Figure 12-9.

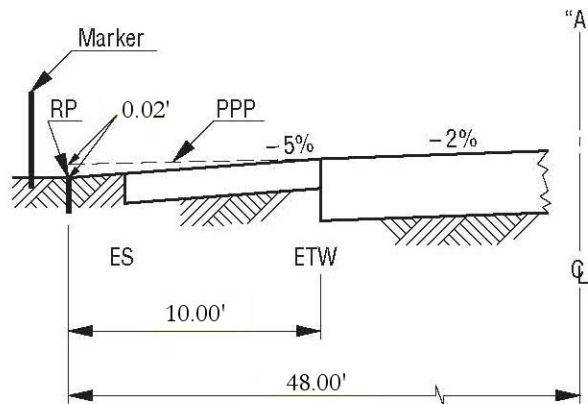


Figure 12-8

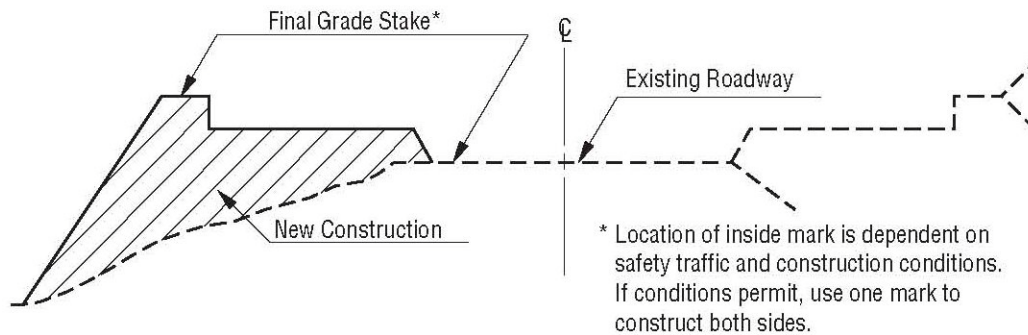


Figure 12-9

**Stake Set:** Reference point and marker stake, at a constant horizontal offset to the edge of the traveled way. Offset should be determined in cooperation with the RE and the Contractor.

**Color Code:** Yellow.

**Spacing:** Space longitudinally every 50 feet along tangents and curves except for curves with a radius under 1000 feet, in which case spacing should be 25 feet.

**Markings:** Stakes should be marked as shown on the following two examples. Notations “a” through “d” are as outlined in Figure 12-8A and 12-9A.

**Setting Tolerance:** Set stakes within 0.10 foot for stationing, 0.03 foot horizontal offset and 0.02 foot vertically of calculated position.

F6S
A 42+40
48 <sup>00</sup> L+
EL 1022 <sup>45</sup>
F0 <sup>02</sup>
0 <sup>00</sup> PPP
10 <sup>00</sup> ETW
TW -2.0%
SHO -5.0%

Figure 12-8A

a.	F6S
b.	A 42+40
c.	48 <sup>00</sup> L+
d.	EL 1022 <sup>45</sup>
e.	F0 <sup>08</sup>
f.	10 <sup>00</sup> ETW
g.	
h.	TW -2%
i.	SHO -5%

Figure 12-9A

- a. “FGS” identifies the stake as a final grade stake.
- b-d. The reference point for the stake is on the 42+40 cross-section, 48.00 feet left of the “A” stationing line. It has an elevation of 1022.45.
- h-i. The superelevations of the pavement surfaces are from the stationing line “out” (left/right). For the example, the traveled way superelevation is –2.0% and the shoulder superelevation is –5.0%. Note: An even superelevation (e.g., 2.0%) also will be marked as 2%, as shown in Figure 12-9A.

Two options and one alternate are used to mark cuts/fills for the final grade stakes. The option used will be determined by Surveys and the RE.

#### Option A:

- e-f. The cut or fill to the plane of the traveled way pavement surface projected to the reference point (PPP); see Figure 12-8. In Figure 12-8A, the PPP is 0.02 foot above the reference point at the reference point.

Note: The line designated in the “f” marking (the “PPP” line) coincides with the line designated in marking “b”, the cross-section line. This is an exception to the general marking concept that lines designated in markings “b” and “f” intersect.

- g. The horizontal distance to edge of traveled way.

**Option B:**

- e-f. The cut or fill and distance from the reference point to the edge of the traveled way; in Figure 12-9A, the traveled way edge is 0.08 foot above and 10 feet from the reference point.

**Checking:** Check stakes visually and by reviewing the electronic stakeout reports and/or survey notes. Randomly check offsets by measuring the distance between LT and RT stakes at the same stationing.

**Alternate C:**

Alternate C is a variation of Options A or B used specifically for super-elevation transitions on projects having pavement widths or staging that require multiple passes with the paving equipment. Surveys sets stakes at the beginning and end stations of super-elevation transitions and at the stations of the even integer percent cross-fall points (e.g., From —4%, -2%, 0%, 2%, 4%, etc. instead of even stationing) throughout the super-elevation transition. This method allows the Contractor to better control the screed slope of the paving machine.

**Spacing:** As needed to set even integers for cross slopes.

All other requirements are the same as Option A or B, as needed.

### 12.5-7 Drainage Stakes

Stakes set for minor drainage structures, pipes, and similar facilities. See Figure 12-10, below.

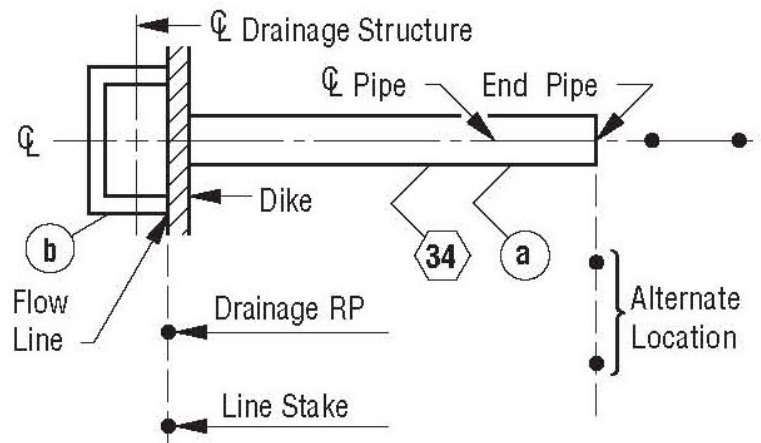


Figure 12-10

**Stake Set:** Reference point and marker and line stakes for the following points in drainage facilities:

Ends of facilities

Grade breaks

Alignment breaks

Junctions

Inlets and similar facilities

Skewed cut-off lines, when necessary as determined by the RE in cooperation with Surveys.

Note: The plumbing of risers and other similar facilities is the Contractor's responsibility; no reference stakes are set for plumbing.

**Color Code:** Blue.



**Spacing:** In general, stakes are only set at the positions noted in the locations above.

When necessary, as determined by the RE in cooperation with Surveys, intermediate reference stakes will be set (a) for staged construction, (b) to provide intervisibility between drainage stakes, and (c) for long, straight runs. When set for long, straight runs, the general spacing of intermediate stakes will be at  $\frac{1}{2}$  (L/2) or  $\frac{1}{4}$  (L/4) of the pipe length, but not less than 100 feet, as conditions permit.

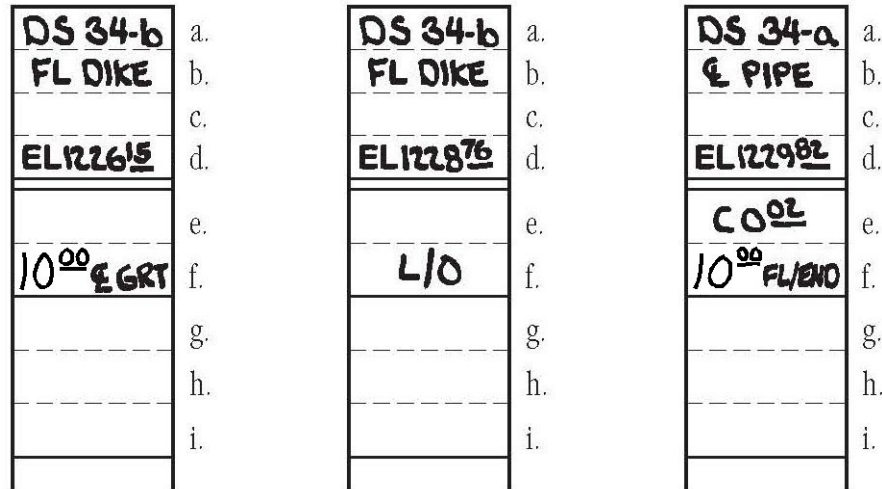


Figure 12-10A

Figure 12-10B

Figure 12-10C

**Markings:** When the plans show control elevations (e.g., inlet and outlet invert elevations), reference stakes will show elevations, not cuts/fills. See Figure 12-10A, 12-10B and 12-10C.

- a. This marking identifies the stake as a drainage stake (“DS”) and the specific drainage facility being staked. If shown on the plans, drainage facilities will be identified by their drainage facility number (system and unit number); such as “34-b” and “34-a” above.
- b. The line defined by the reference stake and its companion line stake (see Figure 12-10); in Figure 12-10A and 12-10B, the flow line of the dike and for Figure 12-10C, the centerline of the pipe.
- d. The reference point elevation; for these examples, 1226.15, 1228.76, and 1229.82.
- e-f. The cut or fill and distance from the reference point to the facility being staked (e.g., grate, gutter, flow line, etc.). If the plans show an elevation for the point being staked, a cut or fill is not provided, unless field adjustments are made. Marking “f” also identifies the line which that point is on.

Note: Generally, the line designated in marking “f” intersects (usually perpendicularly) the line defined by the stake pair (stake marking “b”). An exception is shown in Figure 12-10C, where the two lines coincide. In these cases, the stake will identify what point is being staked, if necessary (e.g., “FL/END”).

For these examples –

Figure 12-10A: The intersection point of the grate centerline and the dike flow line is 10.00 feet from the reference point.

Figure 12-10B: This is a “line only” point which together with the Figure 12-10A stake defines the flow line along the dike at drainage facility 34-b.

Figure 12-10C: The flow line at the end of drainage facility 34-a is 0.02 feet below and 10.00 feet from the reference point.

**Setting Tolerance:** Set stakes within 0.03 foot horizontally and 0.02 foot vertically of calculated position. (Vertical tolerance is only applicable if a specified elevation is being set.)

**Checking:** Check stakes visually, taping between stakes, and by reviewing the electronic stakeout reports and/or survey notes.

### 12.5-8 Curb Stakes

In some cases, one set of stakes may be used for several purposes, such as slopes, final grades and curbs. See Section 12.1, “Policy.”

**Stake Set:** Reference point and marker stake at a constant horizontal offset distance from the flow line. See Figure 12-11.

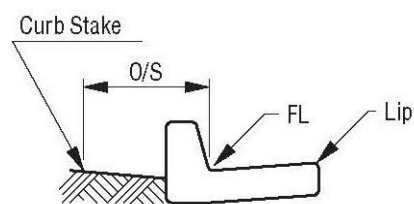
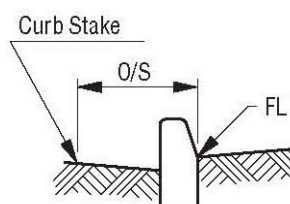


Figure 12-11



CS B-2	a.
A150+40	b.
21 <sup>00</sup> L+	c.
EL 1226 <sup>08</sup>	d.
C 0 <sup>11</sup>	e.
3 <sup>00</sup> FL	f.
	g.
F 0 <sup>16</sup> LIP	h.
	i.

Figure 12-11A

**Color Code:** Blue

**Spacing:** Space longitudinally every 50 feet and at beginning and end of curb and beginning and end of horizontal and vertical curves. When grade is less than 0.3 percent or radius of curvature is less than 1000 feet space every 25 feet. A lesser spacing may be used for flares, tapers or curb returns when necessary, as determined by the RE.

Curb returns are typically staked based on the length of curve at gutter line. Curb returns having a length of curve less than 10' are staked at only the BCR and ECR.

Curb returns having a 10' to 20' length of curve are typically staked at the BCR, ECR, and  $1/2 \Delta$ . Curb returns having a length of curve greater than 20' are typically staked at the BCR, ECR, and  $1/4 \Delta$  intervals. Refer to Table 12-2.

Curb ramps are constructed by the Contractor from the dimensions in the Construction Details and Standard Plans. See Section 12.5-14. Additional stakes may be set if requested by the RE. When practicable, a radius point may be staked to facilitate construction for curb returns having a radius of 25' or less. No other line stakes are set.

**Table 12-2 Typical Curb Return Staking Intervals**

Length of curve at gutter or curb flow line	Number of equal length segments for staking	Points typically staked
$L < 10'$	1	BCR and ECR
$10' \leq L \leq 20'$	2	BCR, $1/2 \Delta$ , and ECR
$L > 20'$	4	BCR, $1/4 \Delta$ , $1/2 \Delta$ , $3/4 \Delta$ , and ECR

**Markings:** Reference stakes show the horizontal offset distance, cuts/fills to the curb flow line, and for non-standard curbs, cuts/fills (from the flow line) to the top-front-edge of the lip. See Figure 12-11A.

a. This marking identifies the stake as a curb stake ("CS") and the type of curb ("B-2"). Curb type is required if changed from the original plans, optional if not.

b-d. These markings follow the general concepts. In Figure 12-11A, the reference point is on the 150+40 cross-section, 21.00 feet left of the "A" stationing line. It has an elevation of 1226.08.

e-f. The cut or fill and distance from the reference point to the curb flow line. In Figure 12-11A, the flow line is 0.11 foot below and 3.00 feet from the reference point. (Note: All curbs are staked to the flow line. The curb flow line is the lowest point of the curb's top surface when in a standard orientation (non-superelevated) or, for curbs without a gutter, the intersection point of the adjacent pavement and the curb face.)

h. The cut/fill from the curb flow line to the curb lip (front-top). This marking is NOT provided for curbs shown in the Standard Plans. A distance to the front-top-lip is NOT provided. In Figure 12-11A, the front-top-lip is 0.16 feet above the flow line.

**Setting Tolerance:** Stakes should be set within 0.10 foot for stationing, 0.03 foot for offset distance, and 0.02 foot vertically of the calculated position. (Vertical tolerance is only applicable if a specific elevation is being set.)

**Checking:** Check stakes visually and by reviewing the electronic stakeout reports and/or survey notes. Randomly check offsets by measuring the distance between LT and RT stakes at the same stationing.

### 12.5-9 Minor Structure Stakes

Minor structure stakes are set for sign bases, lighting and signal foundations, other foundations, and similar miscellaneous structures.

Where minor structures are controlled by adjacent construction staking or adjacent facilities, no Department-furnished stakes are provided. Where Department-furnished construction stakes are necessary, as determined by the RE, reference stakes are set which establish the location, elevation, and alignment (orientation) for the minor structure. See Figure 12-12.

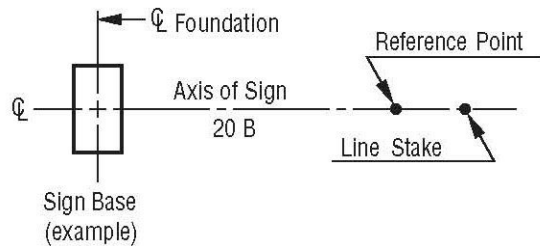


Figure 12-12

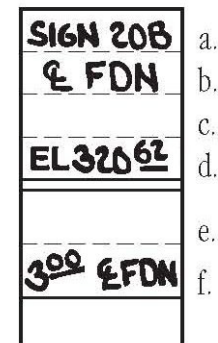


Figure 12-12A

**Stake Set:** A reference point and marker stake and a line point with a guard stake at an offset that allows for excavation clearance.

**Color Code:** Orange

**Spacing:** N/A

**Markings:** See Figure 12-12A.

- a. This marking identifies the minor structure being staked; in Figure 12-12A, a sign. If shown on the plans, minor structures will be designated by their identification number. In Figure 12-12A, “20B” is the sign number shown on the plans.
- b. The line defined by the reference stake and its companion line stake; in Figure 12-12A, the centerline of the sign foundation.
- d. The reference point elevation; example, 320.62.
- e-f. The cut or fill and distance from the reference point to the specific point being staked. If the plans show an elevation for the point being staked, a cut or fill is not provided, unless field adjustments are made. Marking “f” also identifies the line which that point is on. In Figure 12-12A, the intersection point of the foundation centerlines (longitudinal and transverse) is 10.00 feet from the reference point.

**Setting Tolerance:** Stakes should be set within 0.03 foot horizontally.

**Checking:** Check stakes visually and by reviewing the electronic stakeout reports and/or survey notes.

### 12.5-10 Abutment Fill Stakes

Abutment fill stakes are special slope stakes. The extent of Department-furnished construction stakes for abutment fills varies depending on the type and complexity of the abutment fill. Typical Department-furnished construction staking is shown in Figure 12-13. Surveys, in cooperation with the RE and Structure Representative, will determine the actual stakes provided.

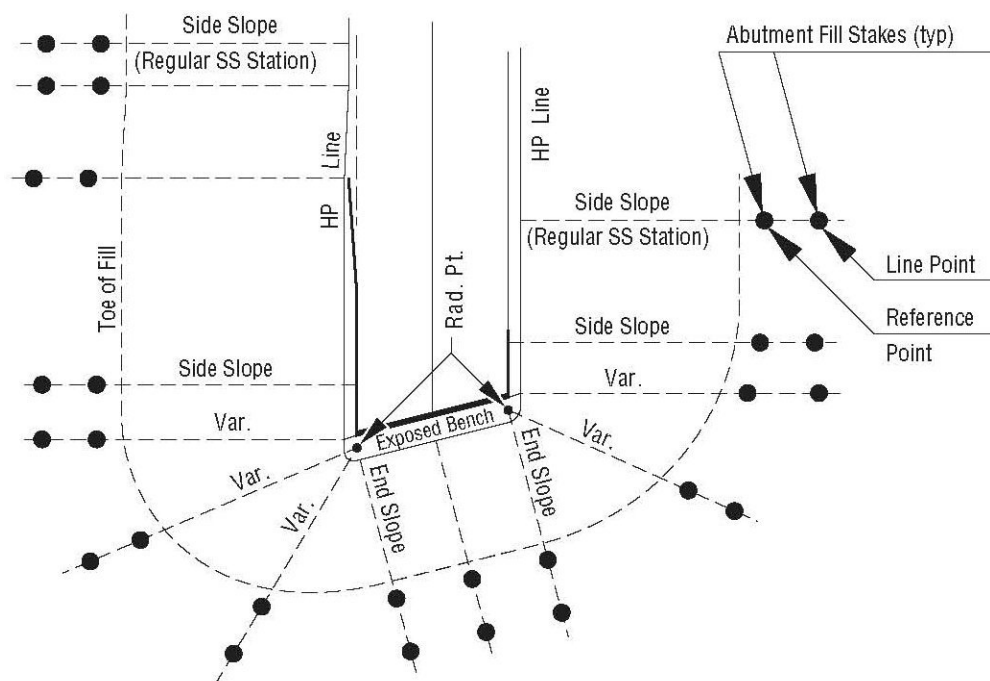


Figure 12-13

**Stakes Set:** A reference point, marker stake and line point (line stakes or the radius point stake may be set for the conic transitions) for the following cross-sections:

Beginnings and ends of hinge point taper transitions.

Last regular side slopes before the conic transitions.

Opposite the exposed corners of abutments; normal or radial to the roadway centerline (required for structures with exposed benches).

Regular intervals along the conic transitions; maximum spacing of 50 feet along toe.

First regular end slopes after the conic transitions; normal to the abutment.

Along the end slope; normal to the abutment.

**Color Code:** Yellow.

**Spacing:** Maximum spacing along end slopes and conic transitions is 50 feet.

**Markings:** See Section 12.5-2, “Slope Stakes – Markings.”

**Setting Tolerance:** Stakes should be set within 0.1 foot horizontally and vertically of calculated position.

**Checking:** Check stakes visually and by reviewing the electronic stakeout reports and/or survey notes.



**12.5-11 Wall Stakes**

Wall stakes are set to reference wall lay-out lines (LOL). This section applies to Sound Walls, all types of Retaining Walls, Soil Nail Walls, Headwalls, Wing Walls, etc. Only one line is to be referenced for each wall, except as noted below. See Figure 12-14.

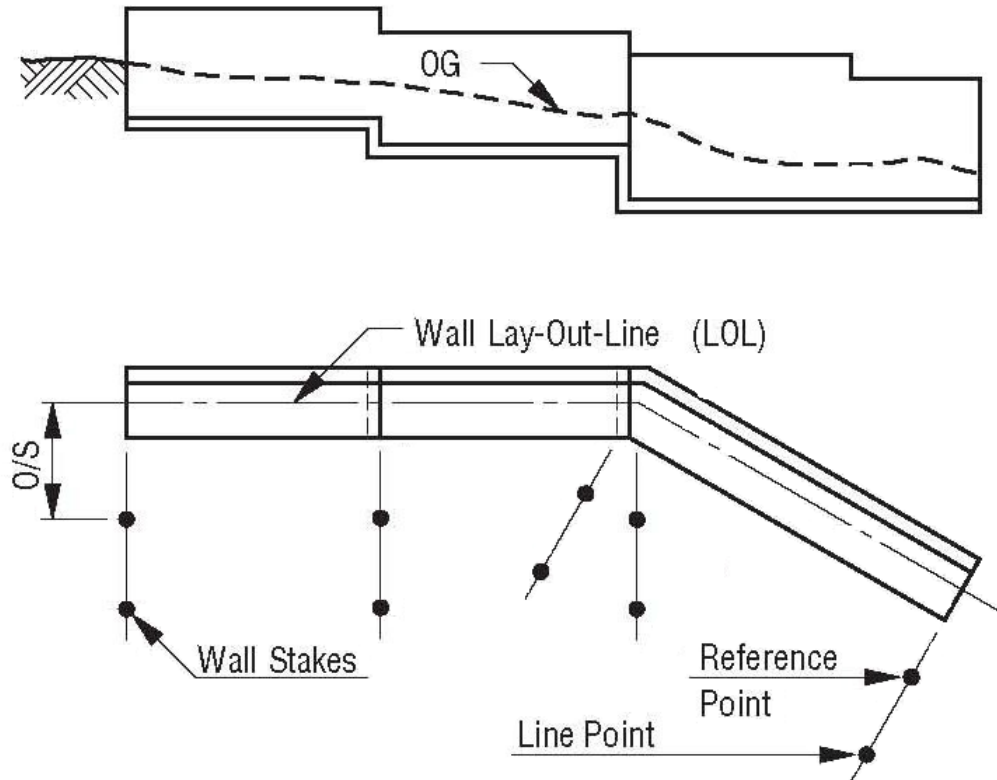


Figure 12-14

**Stakes Set:** A reference point, marker stake and line point with a guard stake.

**Color Code:** White.

**Spacing:** Stakes are set at the beginning and end of each wall, beginnings and ends of curves, and LOL angle points. The spacing of stakes longitudinally along the LOL

off-set line is determined by Surveys, in consultation with the RE and the Structure Representative, but will not be less than 20 feet, or exceed 50 feet. A set of intermediate stakes may be set for sloping tieback or soil nail walls over 30 feet in height.

**Markings:** Reference stakes show the horizontal offset distance to the LOL and elevations, not cuts/fills. Refer to Section 12.5-9, “Minor Structure Stakes.”

**Setting Tolerance:** Stakes should be set within 0.03 foot horizontally of calculated position and 0.02 foot relative to the other reference points. Vertical tolerance is 0.02 foot. (Vertical tolerance is only applicable if a specific elevation is being set.)

**Checking:** Check stakes visually and by reviewing the electronic stakeout reports and/or survey notes.

## 12.5-12 Major Structure Stakes – Ground

The extent of Department-furnished construction stakes for major structures such as bridges varies, depending on the type and complexity of the structure and its construction. In most cases GPS equipment will not be used by Caltrans or the Contractor to set major structure stakes. Department-furnished staking of footings (bents, abutments, wingwalls, etc.) is normally provided by Surveys. Typical Department-furnished construction staking is shown. Surveys, in cooperation with the RE and the Structure Representative, will determine the actual staking provided. See Figure 12-15.

No stakes are set by Surveys for the following:

- The locations of individual piles
- Individual pile cutoff elevations
- Falsework

**Stakes Set:** For footings (Bents, Abutments, and Wingwalls), two reference points, each with a marker stake that provides elevation, distance and line references for the controlling lines. A third reference stake, for “line only,” is set when required by the construction conditions, as determined by the Surveys personnel in cooperation with the Structure Representative. Generally, for footings, bents, and abutments, a set of reference stakes is established on each side of the structure (see Figure 12-15).

**Color Code:** White.

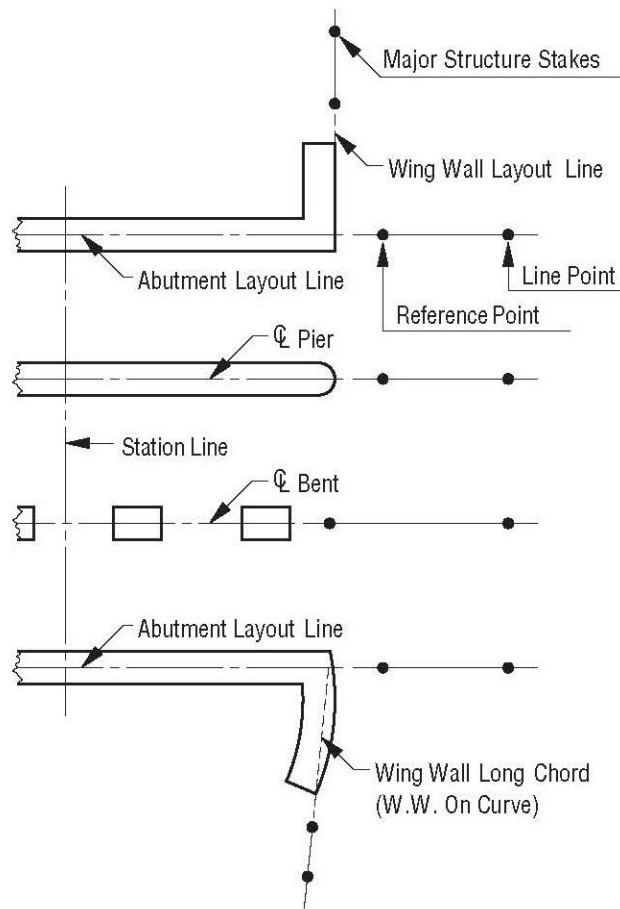


Figure 12-15

**Markings:** See Figure 12-15A and 12-15B. Reference stakes for major structures provide references for only the controlling lines for the structure and reference elevations.

The identification of the major structure component being staked (abutment, wing-wall, pier, etc.); for Figures 12-15A and 12-15B, Abutment 1 and a wingwall.

The *line* defined by the reference stake and its companion reference stake(s); for each example shown, this is the lay-out-line of the component. Generally, for major structures, a set of stakes will consist of two reference stakes, each providing line, distance, and elevation. Where appropriate, a third “line only” stake also will be set.

The reference point elevation; for Figures 12-15A and 12-15B, 715.48 and 715.12.

The distance from the reference point to the *line being referenced* and the identification of the *line* which is being referenced. The distance is measured along the line identified

by stake markings “b” (for Figures 12-15A and 12-15B, the lay-out line). Cuts or fills are not provided for major structures.

ABUT #1
LOL
EL 715.48
28 <sup>00</sup> LOL

- a.
- b.
- c.
- d.
- e.
- f.
- g.
- h.
- i.

Figure 12-15A

WW
LOL
EL 715.12
ABUT #1
12 <sup>00</sup> LOL

- a.
- b.
- c.
- d.
- e.
- f.
- g.
- h.
- i.

Figure 12-15B

For Figures 12-15A and 12-15B, the distance along the lay-out line from the reference point to the “A2” stationing line is 28.00 feet, and the distance, along the lay-out line from the reference point to the Abutment 1 lay-out-line is 12.00 feet.

**Setting Tolerance:** Stakes should be set within 0.03 foot horizontally and 0.02 foot vertically. (Vertical tolerance is only applicable if a specific elevation is being set.)

**Checking:** Check staking visually and by reviewing the electronic Stakeout Reports and/or survey notes. As a further check, distances between stakes set on the ground should be measured and compared against plan distances.

### 12.5-13 Major Structure Stakes – Superstructure

The extent of Department-furnished control stakes for superstructures is a combination of stakes provided by Surveys and the Structure Representative. The types, density, and placement of control stakes are dependent on the complexity of the superstructure. Surveys, in cooperation with the RE and the Structure Representative, will determine the actual staking provided.

This section describes the typical superstructure staking provided by Surveys. The Structure Representative may provide additional Department-furnished control stakes for the superstructure.

#### Stakes Set:

Temporary bench marks on the tops of columns marked “TBM”.

One set of control stakes at a constant offset to the alignment set on the soffit forms. The Structure Representative will determine the offset.

Color Code: White

**Spacing:** Space longitudinally every 25 feet.

**Markings:** Stakes should be marked “STR” for structure stake and identify the alignment station and offset.

See figure 12-16.

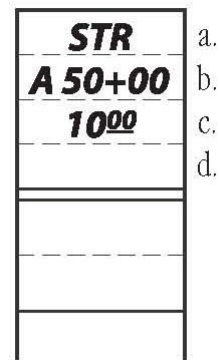


Figure 12-16

**Setting Tolerances:** Stakes will be set to within 0.02 feet horizontally or 0.02 feet vertically. Note: The control stakes on the soffit will not have vertical information.

**Checking:** Check stakes visually and by reviewing the electronic stakeout reports and/or survey notes.

### **12.5-14      Miscellaneous Stakes**

With the exception of contour grading, miscellaneous staking is generally the responsibility of the Resident Engineer. The RE's requests for Surveys to provide miscellaneous stakes should be approved by Surveys.

#### **Contour Grading**

Department-furnished construction stakes for contour grading vary with the design and terrain. Surveys, in cooperation with the RE, will determine the Department-furnished stakes provided. Generally, stakes are set at a longitudinal spacing of 50 feet. A "grid" pattern of stakes might be used for areas of relatively shallow fills or cuts. Stakes should be marked in the same manner as rough grade stakes. See Section 12.5-5.

#### **Utilities**

Utility work generally is controlled by adjacent construction staking or adjacent facilities, and no Department-furnished stakes are set. If separate stakes are necessary, as determined by the RE in cooperation with Surveys, Department-furnished stakes will be provided in the same manner shown for similar roadway work.

Department-furnished stakes are set for water and sewer lines at a longitudinal spacing of 50 feet; a 25 foot spacing will be used when the grade is less than 0.3 percent or when the radius of curvature is less than 1000 feet.

#### **Sidewalks**

Department-furnished stakes are set only as determined necessary by the RE for sidewalks that meander or change grade independently as compared to controlling elements such as adjacent curbs or nearby building foundations.

#### **Signs**

When necessary, as determined by the RE, Department-furnished stakes are provided to locate signs. (See Section 12.5-9, "Minor Structure Stakes.")

#### **Channels, Dikes, and Ditches**

Major channels and dikes are controlled by Department-furnished slope stake references. For ditches, Department-furnished reference stakes are provided for line and grade breaks, when necessary, as determined by the RE.

**Subsurface Drains**

Department-furnished stakes are set only as determined necessary by the RE. Set stakes for subsurface drains in the same manner as for drainage pipes (see Section 12.5-7, “Drainage Stakes”). Stabilization trenches and permeable blankets are controlled by Department-furnished slope stakes or contour grading stakes (see Section 12.5-2).

**Overside Drains**

For straight discharge overside drains, Department-furnished stakes (references) are provided only for longitudinal location. Alignment and grade breaks will only be staked at the direction of the RE.

**Markers**

Markers are located by Department-furnished stakes (or references), as determined necessary by the RE.

**Railings and Barriers**

Where railings and barriers are controlled by adjacent construction staking or adjacent facilities, no Department-furnished stakes are provided, except stakes that establish the beginning and end of each railing or barrier. All staking is to the base of the barrier only.

Where Department-furnished construction staking is necessary, as determined by the RE, stakes (references) are generally provided for alignment and grade at a spacing of 50 feet along the facility. 25 foot spacing will be used: (a) when the radius of curvature is less than 1000 feet; (b) in areas of superelevation transition; and (c) within 100 feet of “conforms” or bridges. A lesser spacing will be used for flares, when necessary, as determined by Surveys.

**Hot Mix Asphalt Dikes**

Department-furnished stakes are provided only at the beginning and end of HMA dikes.

### **Box Culverts**

Department-furnished reference stakes are set for the lay-out-lines of box culverts in the same manner shown in Section 12.5-11, “Wall Stakes.” Headwalls and wingwalls are referenced as shown in Section 12.5-12, “Major Structure Stakes–Ground.”

### **Pavement Markers**

Department-furnished references are provided in accordance with the contractual requirements. If the contract does not specify any requirements, one row of references will be provided per traveled way. References will be set every 150 feet on tangents, every 100 feet on curves with a radius of over 2000 feet, and every 50 feet on curves with a radius of under 2000 feet.

Normally, no Department-furnished references will be provided when pavement markers are placed on portland cement concrete pavement.