9 Control Surveys

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9 Control Surveys

Introduction

Control surveys establish a common, consistent network of physical monuments that are the basis for the horizontal and vertical location of transportation improvement projects and facilities. Primary control monuments meet the requirements for the California Spatial Reference Network[1] (CSRN) as defined in the Public Resources Code §8850, et seq. Project control monuments provide consistent and accurate horizontal and vertical control for Caltrans projects. Supplemental control surveys are a densification of the project control to facilitate photogrammetric, planning, engineering, construction, and right of way, post construction, and as-built surveys.

These policies, standards, and procedures apply to control surveys for all Caltrans-involved transportation improvement projects:

- All Caltrans primary control surveys will be based on the California Spatial Reference Network (CSRN) and/or the National Spatial Reference System (NSRS). Global Navigation Satellite System (GNSS) surveys will be based on a minimum of three monuments.
- Control surveys must be performed in compliance with appropriate standards.
- The preferred primary control monuments are active stations such as CORS (Continually Operating Reference System) or CGPS (Continuous Global Positioning System) stations with a 95% network accuracy of 1 centimeter (cm) or less. Passive monuments that are a part of the NSRS observed by GNSS should still be viable primary control for projects, and when practical, should be included in the network as held control that may be weighted if proof of necessity exists.
- When using active stations (CORS / CGPS) as primary control, horizontal project control monuments will meet the 1 cm network accuracy standards if possible.
- All project control must, at a minimum, meet the 2 cm network accuracy standards.
- All vertical project control surveys will be based on at least two (2) North American Vertical Datum of 1988 (NAVD 88) or California Orthometric Height (COH 88) stations[2]. The minimum vertical accuracy standards for project control are Third Order.
- All Height Modernization Surveys (Ht. Mod.) will be based on National Geodetic Surveys (NGS) standards. Ht. Mod surveys are appropriate when conventional leveling is neither economical nor timely for projects requiring NAVD 88 vertical datum.

Exceptions to the above policy are described in Chapter 4, Section 4.6.

[1] See Chapter 4.1-1

[2] See Chapter 4, *Survey Datums*

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9.1 General Policy

Primary control surveys provide the geodetic foundation for Caltrans project control surveys along transportation corridors. Primary control surveys are typically district or region wide networks tied to the CSRN or NSRS. Work to perform periodic recovery and maintenance of primary control stations is supported through the Basic Control Surveys[3] program administered by the Headquarters Office of Land Surveys (OLS). Consultation with OLS is recommended prior to conducting any basic control surveys activities in each district.

Project control surveys will be performed when Caltrans-involved transportation improvement projects require land surveys. California Coordinate System of 1983 (CCS83) coordinates will be used to define the spatial positions of project facilities.

Horizontal project control surveys will be based on (tied and adjusted to) three or more CSRN and/or NSRS stations. If a horizontal project control survey network "tie" to the nearest CSRN or NSRS station exceeds 12 miles, establishment of additional station(s) shall be considered. See Chapter 4, Section 4.1, "Horizontal Datum" and Section 9.4-2 of this Chapter.

When feasible, horizontal project control will be established using GNSS surveys complying with Caltrans 1 cm accuracy standard. When GNSS survey methods cannot be used for all or part of a horizontal project control survey, a Total Station Survey System (TSSS) traverse network meeting the Caltrans Second Order, Class II or 2 cm Network Accuracy standard is acceptable. See Chapter 5, "Classifications and Accuracy Standards."

Vertical project control surveys will be performed when Caltrans-involved transportation improvement projects require elevations to define the positions of fixed works. Vertical project control surveys will be based on a single, common vertical datum to ensure that various phases of a project and contiguous projects are consistent. The current vertical datum for Caltrans-involved improvement projects is the North American Vertical Datum of 1988 (NAVD 88). See Section 4.2, "Vertical Datum," for a description of NAVD 88 and exceptions to its use. All vertical project control survey work will be done to the Caltrans Third Order survey accuracy standard, or higher. See Chapter 5, "Classification and Accuracy Standards."

Vertical project control will be tied to a minimum two NAVD 88 or COH88 stations. All GNSS project control monuments must be a part of the vertical network, in order to establish the difference between GNSS ellipsoid heights and orthometric heights for the project.

All Ht. Mod surveys must be tied to at least four NAVD 88 or COH88 stations, two at each end per NOAA Technical Memorandum NOS NGS-58 and NGS-59.

Primary Control surveys must be documented by filing a Record of Survey. Project Control surveys must be documented by filing a Record of Survey or a signed and sealed Project Control Diagram (See figure 9.6-2A).

[3] http://landsurveys.onramp.dot.ca.gov/geodetic-surveys

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9.2 Planning and Research

Responsibility

A project surveyor will be assigned to a project requiring land surveys. For the purpose of this Chapter, the term "Project Surveyor" refers to that person in responsible charge of preparing, signing and sealing the control record of survey or project control diagram. The project surveyor, in consultation with the field supervisor and party chief, is responsible for designing and establishing the project control network.

Planning

Project control surveys should provide adequate and permanent horizontal and vertical survey control for engineering, construction, right of way, and final monumentation surveys for the duration of the project. A work plan for establishing the project control should be developed early in the planning phase after consulting these individuals:

- Project Manager
- Project Delivery Team (PDT)
- District Surveys Office Manager
- District Surveys Field Manager

Designing the project control network so it will allow surveys to meet the needs of all PDT members through the life of the project is critical. Key steps in the control planning process are:

- Research the existing horizontal and vertical control networks.
- Recover and evaluate existing control.
- Design the project control network and select the survey equipment and methods to accomplish the required precision and accuracy.
- Develop a survey work schedule that meets the needs of the project schedule.
- Plan supplemental control.
- Safety and sustainability considerations.

If possible, project control should be designed so project control monuments serve as both horizontal and vertical control.

Research

The project surveyor will conduct a thorough search of Caltrans, National Geodetic Survey (NGS), California Spatial Reference Center (CSRC) and other agency records to determine the availability of existing control in the project area. Passive monuments such as HPGN-D with prior datum tags may be used for primary control after they have been checked for stability and their values have been confirmed by re-observation. Using existing Caltrans monuments and datum tags that conform to adjoining projects may be necessary.

New coordinate values for existing control, based on the CSRN/NSRS, should be determined by network adjustment of field observations. All primary control monuments must have the same datum tag and epoch date per PRC §8815.3. All primary control monuments must have network accuracy estimates better than or equal to the survey accuracy you are attempting to achieve.

Researching time series plots of CORS/CGPS stations should be part of the project research phase to ensure horizontal and vertical stability of each active station. Passive stations in the NSRS have both horizontal and vertical stability ratings on the NGS datasheets. Only orthometric heights shown to two decimal places (U.S. Customary) on NGS datasheets are acceptable for vertical project control. Research for vertical project control may be expanded beyond Caltrans surveys files and NGS to include other State, Federal, County and local agency bench marks.

Below are links to resources for researching CORS/CGPS time series plots

http://geodesy.noaa.gov/CORS/coord_info/plots.shtml
http://pbo.unavco.org/data/gps
http://www.unavco.org/instrumentation/networks/status/pbo
http://sopac.ucsd.edu/sector.shtml

9.3 Office Preparation

The project surveyor, in consultation with the field supervisor and party chief, is responsible for the development of the instructions and information (field package) for performing required control surveys. Surveys office staff, in support of the project surveyor, prepares a field package using information obtained from research, with other compiled and computed data. Field packages should contain all the information and data to efficiently complete the field work required for establishment of control networks. Typical information to include in the field package is:

- Copy of the original survey request, with preliminary project mapping
- Project datum and control sheet (Chapter 4, Survey Datums Form 4.1)
- Reference ties and related data for existing horizontal and vertical control monuments, including "to reach" information and/or NGS datasheets
- Copies of Caltrans right of way maps, monumentation maps, current satellite imagery, and pertinent research materials (record of survey maps, parcel maps, and subdivision maps)
- Recommended locations of future project or supplemental control monuments. For projects where the contractor will use Automated Machine Guidance (AMG), supplemental control will be set per Chapter 12.1- 6 of the Caltrans Surveys Manual.

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9.4 Field Work

9.4-1 Reconnaissance

Prior to initiating a primary or project control survey, a thorough search and recovery of existing horizontal and vertical control monuments in the area is required. Also, field reconnaissance may be required before final control network planning is accomplished and field work begins. Recovered control monuments must be evaluated for safety, stability, sky view, and multipath error before using as a basis for new control surveys. All recovered points should be fully described in the survey notes. Unrecovered points must be documented in the project report. If NGS published marks are destroyed, a mark recovery report should be submitted. http://www.ngs.noaa.gov/cgi-bin/recvy_entry_www.prl

9.4-2 Primary Control Surveys

Primary control surveys establish stations with common datum tags / epochs that may be used for multiple highway improvement projects. To maintain a high degree of relative accuracy between stations, they are spaced along highway corridors approximately four to 10 miles apart. These corridor control stations, along with CORS and CGPS active control stations, are primary control for all of Caltrans surveying efforts.

Primary control stations may be passive monuments, usually set as part of an HPGN/HPGN-D or NGS Ht. Mod survey having a published horizontal network accuracy of 1 cm or better. The Ht. Mod monuments have a network vertical accuracy of 2 cm or better.

Although CORS, CGPS, and passive monuments may have previous epoch date positions on their respective data sheets under “Superseded Survey Control”, using superseded values is not recommended for survey control. However, earlier epoch date values may be used, provided appropriate adjustments are made to horizontal positions in accordance with PRC 8815.3, and the final adjustment complies with Caltrans Primary Control Accuracy Standards.

Please see Chapter 4.6-2(a) and (b) for further explanation.

Each District/Region should develop a systematic plan for improving and maintaining primary control networks. District-wide or area-wide primary control surveys are the preferred method for establishing project control along State highway corridors. When large area densification surveys are planned, cooperative agreements for performing the work may be pursued with other agencies and involve private sector surveyors in consultation with OLS, CSRC, and the NGS Pacific Southwest Regional Geodetic Advisor.

When ties to primary control stations, to establish project control, exceed 12 miles, densification of higher order control stations will be considered. Exceptions to this policy will be determined by the District Surveys Manager based on current and future project development needs, statutory requirements, and resources.

Method

Primary Control surveys must be performed using GNSS survey methods. See Chapter 6, "Global Positioning System (GPS) Survey Specifications."

> **Note:** Survey procedures, equipment, results, and documentation must conform to NGS specifications if survey results will be submitted to NGS for inclusion in the National Spatial Reference System (NSRS).

Accuracy

Surveys should be performed in compliance with Caltrans 1 cm horizontal survey standards (see Chapter 5, "Classification and Accuracy Standards"), referenced and adjusted to four CSRN and/or NSRS stations (must have a minimum of three).

Monumentation

Passive monuments will be along transportation corridors in secure locations. The station site will be selected with safety considerations given highest priority for the land surveyor and the traveling public. Monuments will be accessible to the public, preferably in a public right of way or easement. Typical locations are:

- Along freeway ramps near the junction of the right of way for the ramp and the local street.
- Within county or city street right of way.
- Bridge abutments (if on piles).
- On public property or at public facilities (canals, parks, etc.).

Select station locations that can be easily described. When several locations are equally satisfactory, choose the one near features that will aid in future monument recovery.

Primary control monuments will be constructed to ensure permanency. Monument type will be chosen to suit the local conditions. Acceptable monuments are described in Chapter 5.8-1.

If the survey results will be included in the NSRS, use Caltrans 2-1/4" monument disks, or brass or aluminum disks specifically designed and manufactured for NGS surveys stamped with the calendar year of the survey and the station identification.

All primary, or project control monuments must be made of metal or concrete, and use brass or aluminum disks or caps.

9.4-3 GNSS Horizontal Project Control Surveys

Horizontal project control surveys establish control for transportation improvement projects. All subsequent horizontal surveys for a project are based on the horizontal project control.

Methods

Most horizontal project control surveys are hybrid projects combining GNSS passive control monuments surrounding the project with total station traverse networks between GNSS azimuth pairs.

See Chapter 6, "Global Positioning System (GPS) Survey Specifications." and Chapter 7, "Total Station Survey System (TSSS) Survey Specifications."

Accuracy

Horizontal project control surveys must be referenced and adjusted to CSRN and/or NSRS stations. Preferred order of accuracy is Caltrans 1 cm. network accuracy. The Caltrans 2 cm network accuracy standards are acceptable when passive primary control monuments are held in the final network adjustment.

Monumentation

- For projects that will require GNSS Real Time Kinematic (RTK) site calibration, a minimum of four passive monuments will be established (see figure 9.4-3A). Each of these monuments must be within a different quadrant relative to the project, and the project must lie within the perimeter of the monuments. These monuments must have both horizontal and vertical coordinates, and will establish the site calibration for all subsequent GNSS RTK surveys performed on the project.
- For projects that will use Total Station Survey System techniques, two sets of "Azimuth Pairs" at the beginning and end of each project is typical (see figure 9.4-3B). Small projects may have a minimum of three monuments. For larger projects, intermediate azimuth pairs should be spaced a maximum of three miles (5 km) apart (where conditions allow) along the project main line, or at major "conform" locations, such as interchanges.
- Project control monuments will be constructed to ensure permanency. Monument type will be chosen to suit the local conditions. Acceptable monuments are described in Chapter 5.8-2.
- Locate monuments to minimize disturbance by construction and to be clear of traffic and accessible, preferably within a public right of way or easement.

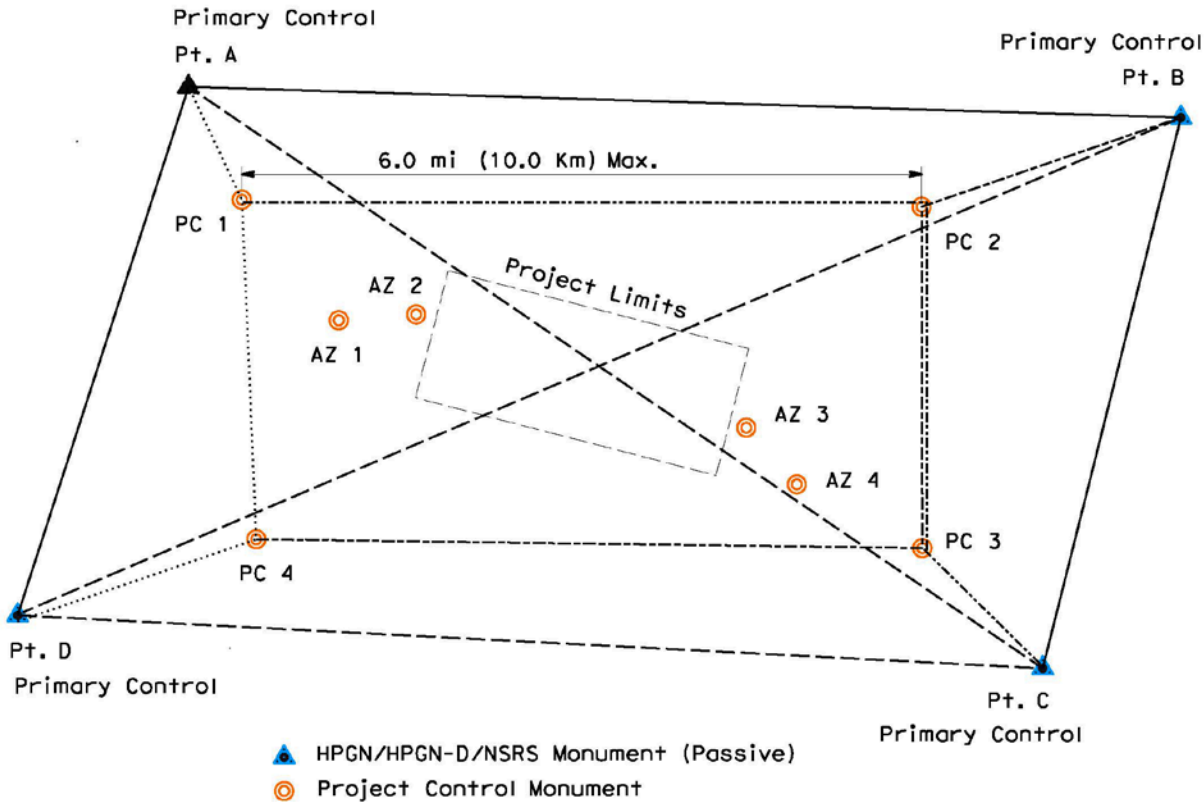

Figure 9.4-3A

Sessions for establishing RTK Project Control

Session 1	Pt. D	Pt. A	Pt. B	Pt. C
Session 2	Pt. A	Pt. C	Pt. D	Pt. B
Session 3	Pt. D	PC 4	PC 1	Pt. A
Session 4	Pt. B	PC 2	PC 3	PC 4
Session 5	Pt. C	PC 3	PC 2	PC 1

Sessions for establishing azimuth pairs (not shown graphically)

Session 6	PC 1	AZ 1	AZ 2	AZ 3
Session 7	PC 1	AZ1	AZ 2	PC 4
Session 8	PC 3	AZ 4	AZ 3	AZ 2
Session 9	PC 2	AZ 3	AZ 4	PC 3

Typical Diagram for GNSS Real Time Kinematic (RTK) Project Control

Figure 9.4-3A shows a simple example of establishing GNSS RTK control for a transportation project. The observed baselines between the project control and the azimuth pairs are not shown. The diagram depicts the use of passive primary control monuments. Active CGPS or CORS stations can be used by requesting the RINEX files from the owner of the active stations.

The diagram reinforces common rules for establishing an RTK network and site calibration. A minimum of four project control points must be observed from the primary control network. All four control points must be in a different quadrant relative to the project limits, and the project must lie within the perimeter of the monuments.

RTK project control accuracy should meet 2 cm or better network horizontal accuracy and third order vertical accuracy. The monuments set must meet the standards in Chapter 5.8-2

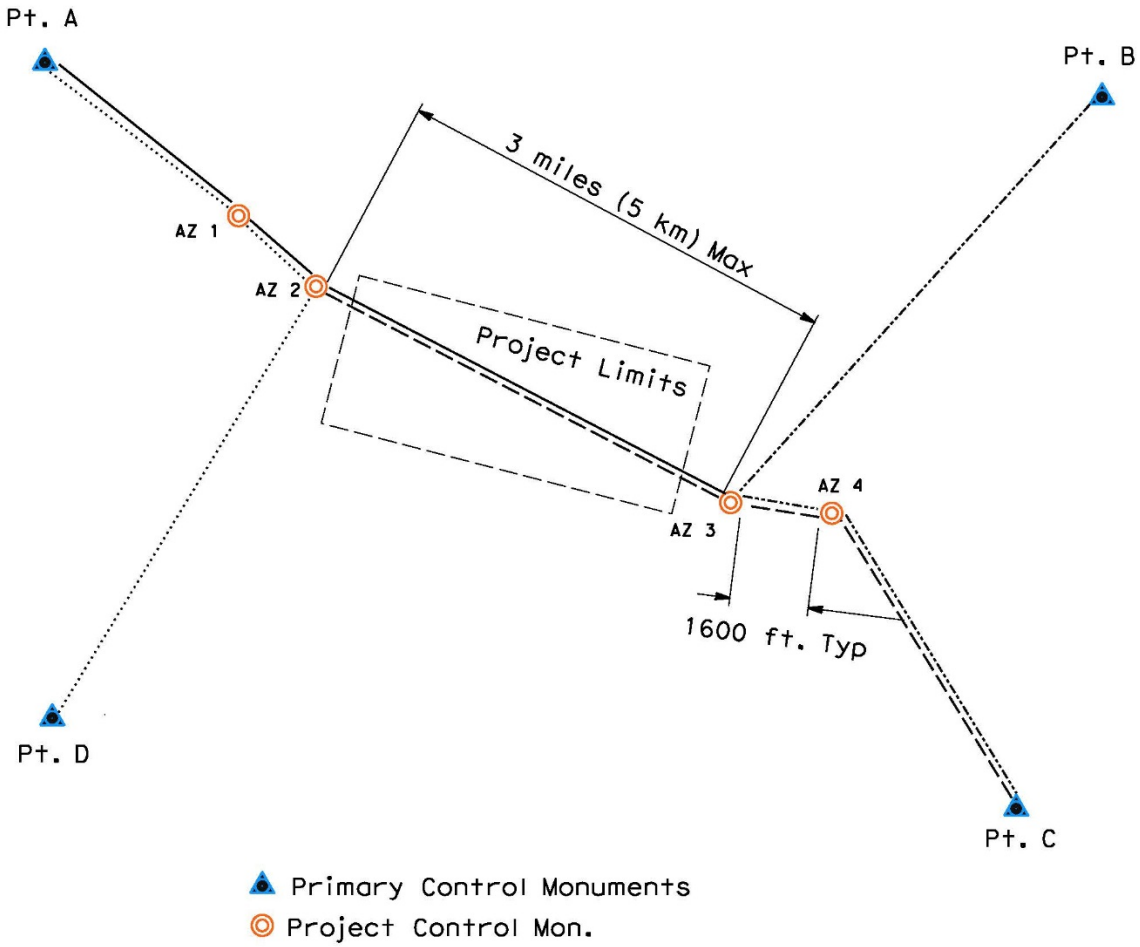

Figure 9-4.3B
Sessions for establishing Azimuth Pairs

Session 1	Pt. A	AZ 1	AZ 2	AZ 3
Session 2	Pt. C	AZ 4	AZ 3	AZ 2
Session 3	Pt. D	AZ 2	AZ 1	Pt. A
Session 4	Pt. B	AZ 3	AZ 4	Pt. C

Typical Project Control for Azimuth Pairs

Figure 9.4-3B is a typical control scheme where buildings, canyons or other terrain features make GNSS observations impractical within the project limits. This diagram shows the base lines between primary and project monuments (baselines between primary monuments not shown). Note that the baselines between GNSS pairs are observed twice. A minimum of three primary control points, (four is recommended) each in a different quadrant in relation to the project, must be used.

The minimum accuracy of the azimuth pairs is both 2 cm network and Second Order, Class II (see Chapter 5.7). A Second Order, Class II, traverse will be run between the pairs, with beginning and closing azimuths. These traverse points are considered project control, and the monuments must meet the standards in Chapter 5.8-2.

Perform cross-ties and redundant measurements whenever possible. Traverses with no cross-ties or redundant observations reduce the advantages of using a least squares adjustment. The traverse network should include multiple triangles. The recommended method is to tie several right of way or land net monuments into the control network. This strengthens the network geometry, and provides a basis for locating future land net monuments using search coordinates. Supplemental Third Order surveys will be based on the initial Second Order traverse.

9.4-4 Total Station Survey System (TSSS) Project Control Surveys

Total Station surveys are performed whenever site conditions do not allow GNSS surveys, or the relative precision required by the survey cannot be met by GNSS techniques. An example of this is cadastral surveys, when the distance between monuments is too close for GNSS techniques to achieve the equivalent of Third Order relative accuracy. (See Chapter 7, Section 7.4-1 and Chapter 10, Section 10.10-4).

TSSS control surveys must be based on inter-visible passive monuments, either published monuments that meet the requirements of Public Resources Code §8801, et seq, or GNSS azimuth pairs set to the required accuracy (see Chapter 5.7).

Methods
TSSS surveys must be performed to Second Order, Class II, standards and specifications. The control network should accommodate redundant observations which will provide freedom for least squares adjustment.

Accuracy
The final adjustment must meet 2 cm network accuracy standards. Individual traverses within each network must meet Second Order, Class II standards and specifications.

Monumentation

- For Second Order traverses, set monuments as required by project conditions, typically 900 to 1800 feet apart. Minimum spacing for monuments is 450 feet.
- Traverse monuments should be inter-visible with at least two other monuments.
- Control traverses must begin and end on known points with both initial and closing azimuths.
- Second Order traverses will not have over fifteen legs between control monuments by the shortest measured route.
- Cross ties to existing centerline and land net monuments are preferred over random points, as they allow new coordinates to be set on existing points, and facilitate transformations between different project datums.

9.4-5 Vertical Project Control Surveys

A vertical project control survey will be performed for each specific Caltrans-involved transportation improvement project that requires elevations to establish the positions of topographic data points or positions of fixed works. The establishment of vertical project control monuments is important because all subsequent project surveys requiring elevations are based on the vertical project control.

Vertical control for projects must be established at all GNSS horizontal control stations and azimuth pairs. When feasible, vertical control for projects should be established at all horizontal control stations. Additional benchmarks should be set to densify vertical control and provide convenient control for photogrammetry, topographic, and construction purposes.

Method

Vertical Project Control can be established using these methods:

- Differential leveling, see Chapter 8, "Differential Leveling Survey Specifications."
- Trigonometric leveling, see Chapter 7 "Total Station Survey System (TSSS) Survey Specifications" or "Interim Specifications for Trigonometric Leveling, Second Order, Class II, National Geodetic Survey – Caltrans, August 4, 1993."
- GNSS can be used to bring NAVD88 to a project. See Section 6.9-2, "Vertical GPS Surveys — Applications" and NOAA Technical Memorandum NOS NGS 59.

Accuracy

Preferred accuracy standard is Second Order, Class II, although Third Order accuracy is acceptable. See Chapter 5, "Classifications and Accuracy Standards."

Monumentation

- Monuments should be spaced as required by project conditions, generally no more than 1500 feet apart.
- Whenever feasible, utilize horizontal project control monuments as vertical control monuments.
- Locate monuments to minimize disturbance by construction and to be clear of traffic and accessible, preferably within a public right of way or easement.
- When feasible, establish a monument at each major structure.
- Set permanent project control monuments per Chapter 5.8-2.

9.4-6 Supplemental Control Surveys

Supplemental control surveys are undertaken to densify project control surveys. Supplemental control is used for establishing aerial mapping control, establishing setup points for engineering surveys, construction staking, locating land net monuments, and setting right of way monuments. Supplemental control points may be used for both horizontal and vertical control.

Supplemental control becomes essential to projects when the contractor is implementing Automated Machine Guidance (AMG) to control line and grade (see Chapter 12.1-6).

Method

- Differential leveling, see Chapter 8, "Differential Leveling Survey Specifications" or trigonometric leveling, see Chapter 7 "Total Station Survey System (TSSS) Survey Specifications" or "Interim Specifications for Trigonometric Leveling, Second Order, Class II, National Geodetic Survey – Caltrans, August 4, 1993."
- TSSS surveys, see Chapter 7 "Total Station Survey System (TSSS) Survey Specifications."
- Global Positioning System, see Chapter 6 "Global Positioning System (GPS) Survey Specifications."

Accuracy

Horizontal supplemental control surveys will meet 0.07 ft. local accuracy or Third Order survey standards. Vertical control must meet Third Order standards. See Chapter 5, "Classifications and Accuracy Standards."

Supplemental Monumentation

Monuments should be set where needed, preferably out of the way of construction and in stable ground. Supplemental monuments may not last the life of a project, and may be set using lesser quality materials. Typically they are 18" pipe or rebar, P.K. nails in paving, chiseled crosses in concrete, or similar materials. The party chief will determine the expected life of the supplemental control monument, and select the proper material accordingly.

Monuments not set to the standards of Chapter 5.8-2 are not vertically stable, and should be checked after any freeze/thaw or wet/dry seasonal cycle.

9.5 Post-Construction Control Surveys

With most construction projects, project and supplemental control points are lost or obliterated due to the new construction. Once the construction has been completed the survey crew should re-establish project control within the project boundary. The re-established project control will be used to complete the final monumentation of the new right of way, or the perpetuation or replacement of lost or obliterated right of way or land net monuments. The post construction project control will facilitate any surveys required by construction for the settlement of claims. Post construction control will be included in the Record of Survey filed by the project surveyor.

Accuracy
Monuments must be tied to the project control network, and set to Third Order or 0.07 ft. local accuracy. Vertical control must meet third-order standards. See Chapter 5, "Classifications and Accuracy Standards."

Monumentation
All post-construction project control monuments must meet the monument standards described in Chapter 5.8. At a minimum, there must be two monuments set at the beginning and ending of the project. They need not be inter-visible, but they must be easily occupied with conventional survey equipment.

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9.6 Office Data Processing and Documentation

9.6-1 Evaluation and Adjustment

All control surveys will be evaluated, checked and adjusted by least squares or compass rule adjustment method, as appropriate, using observation equations before being used as a basis for any project survey.

The project surveyor assembles all research materials and completed field data into a project control survey file. The file is then evaluated by:

- Reviewing field notes for completeness and accuracy.
- Reviewing all closures (residuals), adjustments, and conformance to standards.
- Reviewing final adjusted horizontal and vertical coordinate values.

9.6-2 Project Control Diagram

The project surveyor will prepare a Record of Survey or a project control diagram (see figure 9.6-2A) for each horizontal project control survey. The diagram will be a schematic drawing of the horizontal network, including a north arrow, title block, survey date, date of diagram preparation, and legend. The diagram will also include a vicinity map, if applicable. The diagram will show the horizontal control monuments established, and the CSRN or NSRS stations used as the basis for the survey with appropriate symbols, monument names, and coordinate table reference numbers, if applicable. Vertical control monuments will be shown in their approximate location on the diagram.

The project control diagram must include a note that bearings, distances, and coordinates are based on the California Coordinate System and another note naming the datum used for vertical control. The California Coordinate System note will state the zone of the system, the datum tag and epoch, project mapping angle(s), and project combination factor(s). All data shown must conform to the mapping requirements of the California Public Resources Code §8813.1, et seq., and the Caltrans *Plans Preparation Manual*[4], Section 2.2. The project control diagram will be shared with the Design Project Engineer to be included in the Project Contract Plans in accordance with appendix QQ of the Project Development Procedures Manual[5].

[4] http://www.dot.ca.gov/hq/oppd/cadd/usta/ppman/default.htm

[5] http://www.dot.ca.gov/hq/oppd/pdpm/other/PDPM-Appendices.pdf

Figure 9.6-2 Project Control Diagram Example

(Replace with 11" x 17" Figure 9.6-2)

The project control diagram should contain a coordinate table which includes:

- Monument designations.
- Horizontal coordinates of each monument (N,E), add elevation if used as vertical control.
- Horizontal network accuracy or orders of accuracy per Chapter 5.3 for existing control used as the basis for the coordinate system.

  http://www.fgdc.gov/standards/standards_publications/
- Horizontal network accuracy or order of accuracy for new control points.
- Descriptions of each monument.
- Bearing and distances of observed lines (azimuth pairs).

The diagram will also show the approximate location and include a table listing all vertical project control monuments, including:

- Vertical control monument designations.
- Elevation of each monument.
- Order of accuracy of vertical net.
- Descriptions of each monument.

The project control diagram will be retained (archived) as part of the project control report.

9.6-3 Project Control Report

The project surveyor will prepare a project control report for each control survey and file the report, with the control diagram, as part of the permanent survey office records. The project surveyor in charge of the project control survey will sign, seal, and submit all documents relevant to the project control survey for archiving. The following should be included in each report:

- Project Identification: County, Route, Postmile, EA, Project ID #., etc.
- Project involved surveyors: project surveyor, field supervisor, party chief, office supervisor, data processor; include professional land surveyor license numbers.
- Survey Specifications/Standards: Statement regarding the specifications and standards used for the survey; i.e., horizontal 1 cm Network Accuracy, vertical Second Order, Class II, per standards dated mm/dd/yyyy.
- Dates of Survey: Dates field work began and ended and date final adjustments were completed.
- Horizontal Survey Method: General description of the survey method used: i.e., static, kinematic, station-observation time, etc.
- Vertical Survey Method: General description of instrumentation used: i.e., bar code, TSSS, three-wire, etc.
- Horizontal Monument Types: General description.
- Vertical Monument Types: General description.
- Instruments: Manufacturer, model, serial number of GPS receivers, type and serial numbers of antenna used, digital level, total station, etc.
- Baseline Software: Name and version of software used to produce baseline vectors and method of data reduction
- Adjustments: Least squares software used, general comments regarding the consistency of accuracy's achieved, explanation of any large residuals, etc.
- Field Comments: Pertinent comments regarding the field surveys: i.e., right of entry directions, observation problems, etc.
- Office Comments: Pertinent, general comments regarding the data processing and adjustment. Including who performed any office adjustments.
- Project Control Diagram: The project control diagram will be included as an attachment to the project control report
- The signed and sealed field survey party report should be included in the project control report.

9.7 References

New York State Department of Transportation – *Land Surveying Standards and Procedures Manual*
https://www.dot.ny.gov/divisions/engineering/design/design-services/land-survey/repository/LSSPM09.pdf

Oregon Department of Transportation – *Survey policy and procedure manual*
https://www.oregon.gov/ODOT/HWY/GEOMETRONICS/docs/SPPMan2015.pdf

Department of the Army US Army Corps of Engineers – *EM 1110-1-1004 Geodetic and Control Surveys*
http://www.georeferencial.com.br/old/material_didatico/entire_geodetic_and_control_surveying.pdf

Department of the Army US Army Corps of Engineers – *EM 1110-1-1005, Control and Topographic Surveying,* 1 January 2007
http://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-1-1005.pdf

Federal Geodetic Control Committee (FGCC) *Standards and Specifications for Geodetic Control Networks (1984)*
http://www.ngs.noaa.gov/FGCS/tech_pub/1984-stds-specs-geodetic-control-networks.htm

National Geodetic Survey – *NOAA Technical Memorandum NOS NGS-58 Guidelines for Establishing GPS-Derived Ellipsoid Heights*
NOAA Technical Memorandum NOS NGS-59 Guidelines for Establishing GPS-Derived Orthometric Heights
http://www.ngs.noaa.gov/heightmod/GuidelinesPublications.shtml

