

FOUNDATION REPORTS
for
BRIDGES

December 2009.v2



DIVISION OF ENGINEERING SERVICES
GEOTECHNICAL SERVICES



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1. INTRODUCTION

1.1 Intent of this Document

The intent of this document is to define the Department's standard of practice for preparation of the Structures Preliminary Geotechnical Report (SPGR), the Preliminary Foundation Report (PFR) and the Foundation Report (FR). Standardized and consistent report presentations for projects statewide benefit the Department's staff, engineering consultants, bidders, and contractors. Geotechnical Services staff as well as any other organization preparing these reports must follow the procedures presented herein.

This document addresses report content only, it does not address the practice (investigations, design procedures, etc.). Policy and procedures relating to foundation investigations and design procedures are presented elsewhere in the Geotechnical Manual.

The following terms, as defined below, are used throughout this document to convey the Department's policy:

Term	Definition
Must, Required	<i>Mandatory Standard.</i> The associated provisions shall be used. There is no acceptable alternative.
Should	<i>Advisory Standard.</i> The associated provisions are preferred practices.
May, Optional	<i>Permissive Standard.</i> Use or application of the associated provisions is left to the discretion of the Geoprofessional.

1.2 Exceptions to Policy

Exceptions to the policy and procedures set forth in this document require prior approval by GS Management. Staff must use the procedure for obtaining approval for an exception, as documented in a memorandum to all GS staff dated December 7, 2009.

1.3 Modifications to this Document

Staff persons who wish to propose changes to this document may do so using the [Geotechnical Services Discussion Board](#).

1.4 Overview of the Foundation Investigation and Reporting Process

Foundation investigation and reporting generally occurs at three stages of the project development process:

- A Structures Preliminary Geotechnical Report (SPGR) to support Advanced Planning Studies, performed during the WBS 150.1530 or the 160.1085 stage
- A Preliminary Foundation Report (PFR) to support Type Selection, performed during the WBS 240.65 stage
- A Foundation Report (FR) to support the design of the structure and its construction, performed during the WBS 240.80 stage



1.5 General Requirements

All phases of the foundation investigation and report preparation must be conducted under the direction of a Civil Engineer or Geologist registered in California, who is competent in foundation engineering for highway structures. The geotechnical professional of record must include his/her State of California registration seal, license number, registration certificate expiration date, and signature on all submittals of Foundation Reports (SPGR, PFR, FR), addenda and/or amendments and Log of Test Borings (LOTB).

Foundation Reports must be developed in accordance with Caltrans requirements including the standards presented herein. They must also conform to generally accepted standards of professional practice and all applicable rules and regulations of the California Board of Professional Engineers and Land Surveyors, the Professional Engineers Act and the Geologist and Geophysicist Act.

1.6 Report Format

A separate foundation report should be prepared for each structure or bridge, except that left, center and/or right bridges for the same structure should be combined.

The numbering convention is for the ease of use of this document. Section numbers should not be used in the reports because some sections may not be applicable. Sections titles must be used.

1.6.1 Consultant-Prepared Reports

Foundation Reports must consist of the following: cover sheet, table of contents, main contents per this document, and appendices. The cover of the report and any addenda/amendments to the report must include the following information: Caltrans District, County, Route, Post Mile Total Project Limits, State-assigned Bridge (or Structure) Number, State-assigned Bridge (or Structure) Name, and Expenditure Authorization (EA) number.

A Log of Test Borings (LOTB) must be drafted and submitted as part of the FR. Relevant As-Built LOTB must also be submitted as part of the FR. Refer to the *Caltrans Soil and Rock Logging, Classification, and Presentation Manual* for direction on the preparation of LOTB and As-Built LOTB.

1.6.2 Internal Reports

For reports prepared by Geotechnical Services staff, Foundation Reports must be prepared using the current departmental memorandum format with the subject line of "Foundation Report for *Structure Name*" or "Preliminary Foundation Report for *Structure Name*" or "Structures Preliminary Geotechnical Report for *Structure Name*".



The LOTB and As-Built LOTB sheets are not to be submitted as part of the FR. Microstation LOTB files and scanned copies of the As-Built LOTB sheets are to be sent to the designer for inclusion within the Contract Plans.

The Appendices do not need to be attached to the Foundation Report. These items must be retained per the GS project archive requirements.

1.7 Report Types

1.7.1 Structure Preliminary Geotechnical Report (SPGR)

The SPGR is required during the early stages of a project to assist Structure Design in the preparation of an Advanced Planning Study. Often the number, location, and type of structures are not completely known. As a result, recommendations may be general, and detailed field investigations are usually not warranted. Typical fieldwork consists of a brief site visit only. The SPGR provides an overview of the existing foundations, site geology, seismicity, and, if possible, recommendations regarding suitable and unsuitable foundation types. If appropriate, the SPGR should also discuss the anticipated field and laboratory work required to support the PFR and FR.

1.7.2 Preliminary Foundation Report (PFR)

The PFR is required during the early stages of a project after completion of the SPGR and Advanced Planning Study, and prior to the Structure Type Selection submittal. Generally more will be known about the number, location, and types of structures, and the PFR is used to expand upon the information provided in the SPGR. The PFR will document existing foundation conditions, provide preliminary structure-specific seismic recommendations, make preliminary foundation recommendations, and identify the need for additional investigations and studies. Typically fieldwork will be minimal, although in certain cases may involve site exploration.

1.7.3 Foundation Report (FR)

The FR expands on data provided in the PFR, documents the results of field exploration and laboratory testing and provides foundation and construction recommendations. The FR becomes part of the contract documents via its inclusion in the Information Handout per Standard Special Provision S5-280, "Supplemental Project Information". As such, unlike the preliminary information presented in the SPGR and PFR, the information presented in the FR (and accompanying LOTB) may be used as a basis to support or defend construction claims.



2. STRUCTURE PRELIMINARY GEOTECHNICAL REPORT (SPGR) AND PRELIMINARY FOUNDATION REPORT (PFR)

The following topics should be addressed in all Structure Preliminary Geotechnical Reports (SPGR) and Preliminary Foundation Reports (PFR). It is expected that as the foundation investigation process proceeds, the level of detail in the PFR will expand upon the content of the SPGR.

2.1 Scope of Work

Summarize the scope and types of work performed to obtain the information supporting the preliminary recommendations.

2.2 Project Description

Describe the project location, existing and/or proposed structure(s), and pertinent project information. For consultant-prepared reports, a site vicinity map indicating the project location must be included in the Appendix.

2.3 Exceptions to Policy

Discuss all exceptions to Departmental policy relating to the SPGR or PFR. Approved "Request for Exception" forms must be included in the Appendix.

2.4 Field Investigation and Testing Program

Provide an overview of the field investigations if performed to support the preliminary foundation recommendations.

2.5 Laboratory Testing Program

Provide an overview of the laboratory-testing program if performed to support the preliminary foundation recommendations.

2.6 Site Geology and Subsurface Conditions

Provide a general description of the project site, geology, and known subsurface conditions. The site data may come from current or past field investigations at or near the structure site, As-Built documents, maintenance records, construction notes, geologic literature, or any other relevant information. The information included within this section may include but not be limited to:

- Topography and geology
- Types of soil/rock
- Pertinent soil conditions or geologic hazards, such as
 - Landslides
 - Embankment failures
 - Ground subsidence
 - Collapse
 - Heave
- Depth to the bedrock



- Groundwater elevation(s) and dates the measurements were made

2.7 Scour Evaluation

Report pertinent scour information including the potential and magnitude of scour.

2.8 Corrosion Evaluation

Report and discuss pertinent site corrosion data.

2.9 Preliminary Seismic Recommendations

The preliminary seismic recommendations must include the following seismic ground motion information:

1. Designation of controlling deterministic scenario (California Minimum, Eastern California Shear Zone, etc) and or fault with fault identification number (FID), style of faulting, dip of fault, maximum moment magnitude earthquake (Mmax)
2. Site-to-fault distance (RRUP)
3. VS30 and how VS30 was estimated.
4. Peak ground acceleration (PGA) of the site.
5. If applicable, list all site factors used (e.g. near-fault factor, basin amplification factor, etc).
6. If site is located within a deep sedimentary basin (as shown in the SDC, App. B), list the depth to rock with a shear wave velocity of 1 km/sec (Z1.0) and 2.5 km/sec (Z2.5).
7. Recommended design response spectrum and a brief explanation of how it was determined (e.g. design response spectrum composed of both deterministic and probabilistic spectra).
8. If applicable, site-specific seismic recommendations using site response analysis and design ground motion time-history, and
9. If necessary, recommendations for in-situ data acquisition and laboratory testing needed for site-specific ground motion analysis, such as necessary depth of borings, gradation, shear wave velocities, strain dependent shear moduli and damping ratios.

Preliminary seismic recommendations must also address seismic hazards such as liquefaction potential, surface fault rupture potential, seismically induced settlement, tsunami and seismic slope instability, as applicable.

If other seismic recommendations are prepared and delivered under separate cover (e.g., fault rupture reports), those reports should be referenced in this section.

2.10 As-Built Foundation Data

Include discussion of relevant As-Built data, such as:

- As-Built LOTB
- Existing types of shallow or deep foundations
- As-Built geotechnical ultimate compressive, tensile, and lateral capacities of existing foundations.
- Recommendations for the ultimate lateral passive resistance of soil located behind abutments



- Construction records such as pile driving logs, pile load test reports, settlement monitoring data, groundwater monitoring notes, etc.

2.11 Preliminary Foundation Recommendations

Provide preliminary foundation recommendations for the proposed structure. Recommendations must include appropriate foundation types and, if possible, specific details such as anticipated pile lengths and bearing capacities. Foundation types that are not applicable or constructible should be identified and briefly discussed.

2.12 Additional Field Work and Laboratory Testing

Describe the anticipated scope and type of fieldwork and testing that may be required to complete the foundation investigation. Discuss the planned site investigation relating to potential need for entry permits, access road construction, lane closures etc.

2.13 Report Copy List

The SPGR and PFR must be addressed to the Structure Designer and copies provided to those listed on the Geotechnical Services report distribution list.



3. FOUNDATION REPORT (FR)

The following topics, if applicable, must be addressed in the Foundation Report.

3.1. Scope of Work

Summarize the scope and types of work performed to obtain the information supporting the foundation recommendations.

Include a statement that the current report supercedes all previous reports (referenced by title and date). For example:

This Foundation Report supercedes the Preliminary Foundation Report for (Structure Name) dated (Date) and the Structure Preliminary Geotechnical Report for (Structure Name) dated (Date).

3.2 Project Description

Describe the project location, existing and/or proposed structure(s), and pertinent project information. The datum used to reference the elevations in the report should be included. For consultant-prepared reports, a site vicinity map indicating the project location must be included in the Appendix.

3.3 Exceptions to Policy

Discuss all exceptions to Departmental policy relating to the investigation or design of the proposed foundations.

3.4 Field Investigation and Testing Program

Provide an overview of the field investigation(s) performed to support the foundation recommendations including the number of boreholes and CPT soundings, and any geophysical testing.

3.5 Laboratory Testing Program

Provide an overview of the laboratory-testing program, if performed, to support the foundation recommendations. Summaries of important test results may be provided, such as the range of unconfined compression test results for rock. Results of other tests such as soil classification must be presented in Appendix IV.

3.6 Site Geology and Subsurface Conditions

Describe the project site, geology, and known subsurface conditions. The site data may come from current or past field investigations at or near the structure site, As-Built documents, maintenance records, construction notes, geologic literature, or any other relevant information. The information included within this section should include but not be limited to:

- Topography and geology
- Types of soil/rock
- Pertinent soil conditions or geologic hazards, such as



- Landslides
- Embankment failures
- Ground subsidence
- Collapse
- Heave
- Depth to the bedrock
- Groundwater elevation(s) and dates the measurements were made

Present only factual information in this section, not how it relates to design and construction. Discussion of the site geology, geological features, and subsurface conditions as they relate to the foundation design and construction must be placed in the *Foundation Recommendations* and *Construction Considerations* sections respectively.

3.7 Scour Evaluation

For water crossings only, incorporate the hydraulic findings outlined in the structure Hydrology/Hydraulics Report, or other information gathered during the site investigation, with geologic and geotechnical information to make recommendations regarding the potential scour depth.

3.8 Corrosion Evaluation

Provide corrosion data for the site in the tabular format presented, and a discussion of the data. If corrosion testing was not completed during the foundation investigation, provide justification for the corrosion recommendations.

Soil Corrosion Test Summary

Location	SIC Number	Minimum Resistivity (Ohm-Cm)	pH	Chloride Content (ppm)	Sulfate Content (ppm)

Note: Caltrans currently considers a site to be corrosive to foundation elements if one or more of the following conditions exist: Chloride concentration is greater than or equal to 500 ppm, sulfate concentration is greater than or equal to 2000 ppm, or the pH is 5.5 or less.

3.9 Seismic Recommendations

Include and update as appropriate the seismic design recommendations presented in the PFR based on new findings and field investigations. Information (e.g. soil parameters, V_{S30} , etc) obtained in recent field investigations should be analyzed to ensure that previous preliminary seismic recommendations are valid. The seismic recommendations must address seismic ground motion, soil liquefaction, surface fault rupture potential, seismically induced settlement, tsunami and seismic slope instability, as applicable.

If other seismic recommendations are prepared and delivered under separate cover (e.g., p-y t-z curves, fault rupture reports), those reports should be referenced in this section.



3.10 As-Built Foundation Data

If not covered elsewhere in the FR, include discussion of relevant As-Built data, such as:

- As-Built LOTB
- Construction records such as pile driving logs, pile load test reports, settlement monitoring data, groundwater monitoring notes, etc.

3.11 Foundation Recommendations

Provide complete and concise foundation recommendations by addressing the topics in the applicable portions of Section 3.11. In cases where the most economical or constructible foundation is not recommended, discuss alternative foundation types and the reasons why those alternatives are not recommended.

3.11.1 Shallow Foundations

Discuss the following:

1. The required minimum footing width (B), length (L), and minimum depth (D) at the bottom of footings or the highest elevation at the bottom of footings.
2. Total calculated settlement as it relates to Tolerable Settlements (provided by Structure Design).
3. A description of the material on which the footing is to be placed.
4. The influence of the new footing on the adjacent structures, including construction activities, must be discussed.
5. The Spread Footing Data Table must be presented in accordance with Bridge Memos to Designers (MTD) 4-1, “*Spread Footings*”.

3.11.2 Deep Foundations

1. Pile Types, Bearing Capacity.
 - a. Identify the specific type(s), sizes, and capacities of piles recommended, and their corresponding locations.
 - b. State how the geotechnical capacities are derived, whether from skin friction and/or end bearing. If both, state how much capacity is derived from skin friction and end bearing. Present skin friction contributions along the pile length in the “*CIDH Pile Skin Friction Zone Elevations*” table, shown in the following example

Example

It is anticipated that concrete placement for the CIDH piles will require slurry displacement methods. The calculated “Nominal Axial Resistance” (Q_n) of all CIDH piles was based on skin friction, Q_s ; end-bearing, Q_b , was not used. The zones used to calculate Q_s of the CIDH piles are shown in Table 1.



Table 1: CIDH Pile Skin Friction Zone Elevations

Support Locations	Skin Friction Zone Start Elevation	Skin Friction Zone End Elevation
Pier 7	65.4 ft	51.4 ft
Pier 8	65.4 ft	53.4 ft
Pier 9	68.5 ft	56.0 ft
Abutment 10 Piles 1, 2	78.0 ft	71.5 ft
Abutment 10 Piles 3, 4	71.0 ft	67.0 ft

To achieve sufficient compressive axial resistance through skin friction, the CIDH piles at Piers 7 through 9 and Abutment 10 require a minimum embedment into granitic rock (see Table 2). If the minimum embedment length is not achieved at the Specified Pile Tip Elevation (SPTE), the pile tip must be lowered until the minimum embedment is achieved and the pile reinforcement and GGL inspection pipes lengthened accordingly.

Table 2: CIDH Pile Rock Socket Embedment Length

Support Location	Top of Skin Friction Zone Elevation	Specified Tip Elevation	Minimum Embedment Length
Pier 7	65.4 ft	48.4 ft	17.0 ft
Pier 8	65.4 ft	50.4 ft	15.0 ft
Pier 9	68.5 ft	53.0 ft	15.5 ft
Abutment 10, Piles 1, 2	78.0 ft	69.5 ft	8.5 ft
Abutment 10, Piles 3, 4	71.0 ft	65.0 ft	6.0 ft

- c. For piles driven through scour layers, liquefiable layers, and/or potentially negative skin friction layers, estimate the pile driving resistance to reach specified tip elevation (STE). The following note may be used to convey this information:

At Pier Number ___ location, the calculated axial geotechnical capacity of the piles above the estimated potential scour/liquefaction elevation of ___ ft, as reported by the Hydraulics Branch has been ignored. When installing the CISS piles at Pier Number ___ location, the contractor should anticipate higher driving resistances (as shown on the Pile Data Table) than would be indicated by the Nominal Resistances shown in the Pile Data Table for the following reasons:

- *The piles will have to be driven through the existing scourable soils above the estimated potential scour elevation of ___ ft.*
- *The overburden pressure from the existing scourable soils above the estimated potential scour elevation has been ignored when calculating the axial geotechnical capacity of the piles but will be present at the time of pile installation.*



- *The calculated geotechnical compressive capacity of the (pile type) pile after installation at Pier Number __ location are calculated to be ____ kips.*
- 2. The recommended STE, Design Tip Elevation (DTE) and related information must be shown in a pile data table formatted in accordance with Bridge Memo to Designers 3-1, “*Deep Foundations*”.
- 3. Special Considerations for Cast-In-Drilled-Hole (CIDH) Piles.
 - a. Steel *casings* are used for constructability.
 - b. Driven steel *shells* are used for pile capacity.
 - c. For CIDH piles with rock sockets (see MTD 3-1), identify the limits of the rock socket for bid/payment purposes.
- 4. Special Considerations for Driven Piles
 - a. When open-ended CISS piles are recommended, state the allowable limits of center relief drilling.
 - b. State the minimum soil plug length required for the design of end bearing for CISS piles.
 - c. State the allowable limits of drilling to assist driven pile installation. (Standard Specs 49-1.05)
- 5. Pile Load Testing
 - a. Identify control zones and associated support locations.
 - b. Identify location, type and STE of the load test pile and anchor piles in a pile data table format.
 - c. State applicable waiting period to allow for soil set-up or relaxation, if any, between pile installation and testing.
 - d. State any “Order of Work” requirements relating to the PLT, production pile installation or pile fabrication.
 - e. State any requirements for dynamic measurements with the Pile Driving Analyzer (PDA).

3.11.3 Approach Fill Earthwork

Provide the following information for earthwork located within 150 feet of the structure.

1. Approach Fills
 - a. When unsuitable materials exist at the site, address removal, replacement and/or re-compaction, and the vertical and horizontal limits of such work.
2. Approach Fill Settlements
 - a. Estimates of the magnitudes of settlement.
 - b. Required waiting period prior to pile installation or footing construction.
 - c. Recommendations for reduced waiting periods.
 - d. When the rate of consolidation of approach fills is controlled by weak underlying soils, specify rates of fill placement along with site monitoring.



3. Additional Considerations
 - a. Use of lightweight fill to reduce the magnitude of settlement.
 - b. Use of wick drains or sand drains to accelerate settlement.
 - c. Use of Geo-synthetic materials to improve shear strength and/or drainage.
 - d. Use other soil improvement technology (densification, grouting, etc.).
 - e. Recommendations of vegetation or pavement for embankment side slopes and bridge approaches.
 - f. Slope protection
 - g. Pre-drilling for any piles through existing embankments (when Standard Specifications 49-1.06 does not apply).

3.12 Notes to Designer

The following are examples of notes that may be included, if applicable.

1. *Should the specified pile tip elevation required to meet lateral load demands exceed the specified pile tip elevation given within this report, Geotechnical Services must be contacted for further recommendations.*
2. *Type "D" excavation is to be shown on the plans at Bent(s) __ location(s).*
3. *Type "A" excavation is to be shown on the plans at Pier(s) __ location(s).*

3.13 Construction Considerations

Construction considerations are specific notes intended for the State's specification writers, construction personnel and contractors. Construction considerations identify relevant Standard Specifications and important design criteria that were used in the geotechnical design of the foundations. Construction considerations should identify subsurface conditions that will be encountered in the field during construction. Specific notes regarding the site geology should be included within the construction considerations section to ensure that both the intent of the geotechnical design is met and construction of the foundation is successful.

Address additional topics if applicable, such as:

- Groundwater and seepage
- Temporary excavations
- Pile cut-off
- Caving conditions
- Presence of cobbles and boulders
- Effects of construction work on adjacent structures.
- Recommended on-site training of construction personnel by GS staff.

3.14 Appendices

The Foundation Report appendices provide detailed information supporting foundation type selection, analyses, recommendations, and construction considerations. These must contain at least the following:



3.14.1 Appendix I: Site Map

Site map indicating project location.

3.14.2 Appendix II: Log of Test Borings

Full-sized Log of Test Boring sheets, including As-Built LOTB.

3.14.3 Appendix III: Field Exploration and Testing

Data acquired from field exploration and testing such as surface geologic mapping and surface geophysical surveys, logs from Cone Penetration, Pressuremeter, Dilatometer, and in-situ Vane Shear Tests, Borehole Geophysical logging, indicator pile tests, Piezometer Readings, etc.

3.14.4 Appendix IV: Laboratory Test Results

1. Soil and rock laboratory test results.
2. Corrosion test results.

3.14.5 Appendix V: Analyses and Calculations

Engineering analyses and calculations supporting the foundation recommendations including all QC/QA signature sheets.

3.14.6 Appendix VI: Exceptions to Policy

Attach all approved “Request for Exception” forms.

3.15 Report Copy List

The FR must be addressed to the Structure Designer and copies provided to those listed on the Geotechnical Services report distribution list.

Revisions

- December 2014: Section 3.11.2 updated. Issued as (December 2009.v2)