Standard Plan Overhead Signs and Electrical Systems

This module presents the Department's standard of practice for the investigation, design, and reporting of foundation recommendations for standard plan Overhead Signs and standard plan Electrical Systems. Standard plan Overhead (OH) Signs include truss, tubular, lightweight and versatile truss from the standard plan "S" sheets. The versatile truss accommodates sign panels, Changeable Message Signs (CMS), and Extinguishable Message Signs (EMS). As of the April 16, 2021 Revised Standard Plans, versatile truss replaces the CMS overhead sign truss of the 2018 Standard Plans.

Standard plan Electrical Systems (hereafter referred to as ES Poles) include signal and lighting standards, flashing beacons, closed circuit televisions (CCTV), vehicle detection systems (VDS), guard posts and pedestrian barriers, and temporary wood posts from the standard plan "ES" sheets.

OH Sign and ES Pole foundation design consists of choosing or confirming standard foundations from the current *Standard Plans* and/or *Revised Standard Plans* (RSP). In cases where the standard foundations do not work, the foundation design process involves collaboration with the Structure Designer in the Office of Design and Technical Services (ODTS) to design project-specific foundations.

For more information on the intent and procedures of standardized designs using Standard Plan sheets, refer to the *Geotechnical Design using Standard Plan and Bridge Standard Detail Sheets* module. The foundation types and pertinent Standard Plan Sheets for OH Signs are presented in Table 1, and Table 2 for ES Poles. For Standard Plans OH Sign and ES Pole Sheet Summary, refer to Appendix A.

Table 1: Standard Plan OH Signs and Associated Foundation Types

OH Sign Type	Foundation Type	2018 Standard Plan
OH Signs-Truss, Single Post	CIDH Pile, Spread Footing	RSP S1, RSP S2, S8
OH Signs-Truss, Two Post	CIDH Pile, Spread Footing	RSP S1, S9, S15
OH Signs-Tubular	CIDH Pile	S30, S36, S37
OH Signs-Lightweight	CIDH Pile, Spread Footing	S49
OH Sign–Versatile Truss, Single Post	CIDH Pile	RSP S100, RSP S104, RSP S105, RSP S114
OH Sign–Versatile Truss, Two Post	CIDH Pile	RSP S100, RSP S109, RSP S110, RSP S114

Table 2: Standard Plan ES Poles and Associated Foundation Types

ES Pole Type	Foundation Type	2018 Standard Plan
ES – Lighting Standards	CIDH Pile	RSP ES-6A, ES-6D, ES-6E, ES-6G
ES – Signal & Lighting Standards	CIDH Pile	RSP ES-7A, RSP ES-7C, RSP ES-7D, RSP ES-7E, RSP ES-7F, RSP ES-7G, RSP ES-7H
ES – Flashing Beacons	CIDH Pile	RSP ES-7J, ES-7K
ES – Pedestrian Barricades	Concrete Backfilled Post Hole	ES-7Q
ES – CCTV Pole	CIDH Pile	RSP ES-16B, RSP ES-16C
ES – CCTV Pole with VDS	CIDH Pile, Spread Footing	RSP ES-16D
Temporary Wood Poles	Manufactured-Sand Backfilled Pole Hole	ES-18A, RSP ES-18B, RSP ES-18C, RSP ES-18D, RSP ES-18E

OH Sign and ES Pole foundation types and sizes shown on the Standard Plans were designed using the following predetermined geotechnical engineering parameters:

- Minimum soil shear strength of 1.5 kips per square feet (ksf) – Cohesive Soil
- Minimum soil friction angle of 30 degree – Non-cohesive Soil
- Minimum unit weight of 120 pound per cubic feet (pcf) – Non-cohesive Soil
- Ground slope flatter than 2H:1V
- Groundwater not present along pile length

The GP is responsible to determine if the conditions at the proposed sign or pole location meet or exceed the minimum design requirements, and to evaluate foundation constructability.

Sites that do not meet the predetermined geotechnical engineering parameters may require a special foundation design. Notify the project engineer when the minimum requirements are not met to determine whether the sign can be relocated or if a special design sign foundation may be required. Special designs for OH Sign and ES Pole foundations must follow the applicable foundation design module. Special design considerations are discussed in this module.

Investigations

The investigation for an OH Sign or ES Pole foundation seeks to identify and characterize the subsurface material, determine if the predetermined design requirements are met, locate the water table (if within the depth of the anticipated foundation), and to identify conditions that might affect the foundation construction, such as caving, the presence of cobbles and boulders, or shallow rock. The “Office Work” and “Site Investigation

(Planning Phase)" procedures in the *Geotechnical Investigations* module could produce findings that confirm with reasonable confidence that the predetermined geotechnical engineering parameters are met, and foundation construction conditions are adequate. In this case, drilling for the "Site Investigation (Design Phase)" should be omitted, and the "no-drill" option utilized. At project locations where groundwater cannot be verified to be outside the pile length, the no-drill option is prohibited.

For borings that readily encounter materials that meet or exceed the predetermined geotechnical engineering parameters, borings need not extend more than 10 feet deeper than the standard plan pile length.

Auger borings are preferred in unsaturated conditions since they mimic the typical construction method for OH Sign and ES Pole CIDH pile foundations. Auger borings provide instant groundwater information to aid in the design of CIDH pile foundations and identify the need for wet construction methods; however, once groundwater is encountered, drilling methods should switch from auger to mud rotary as the boring proceeds deeper.

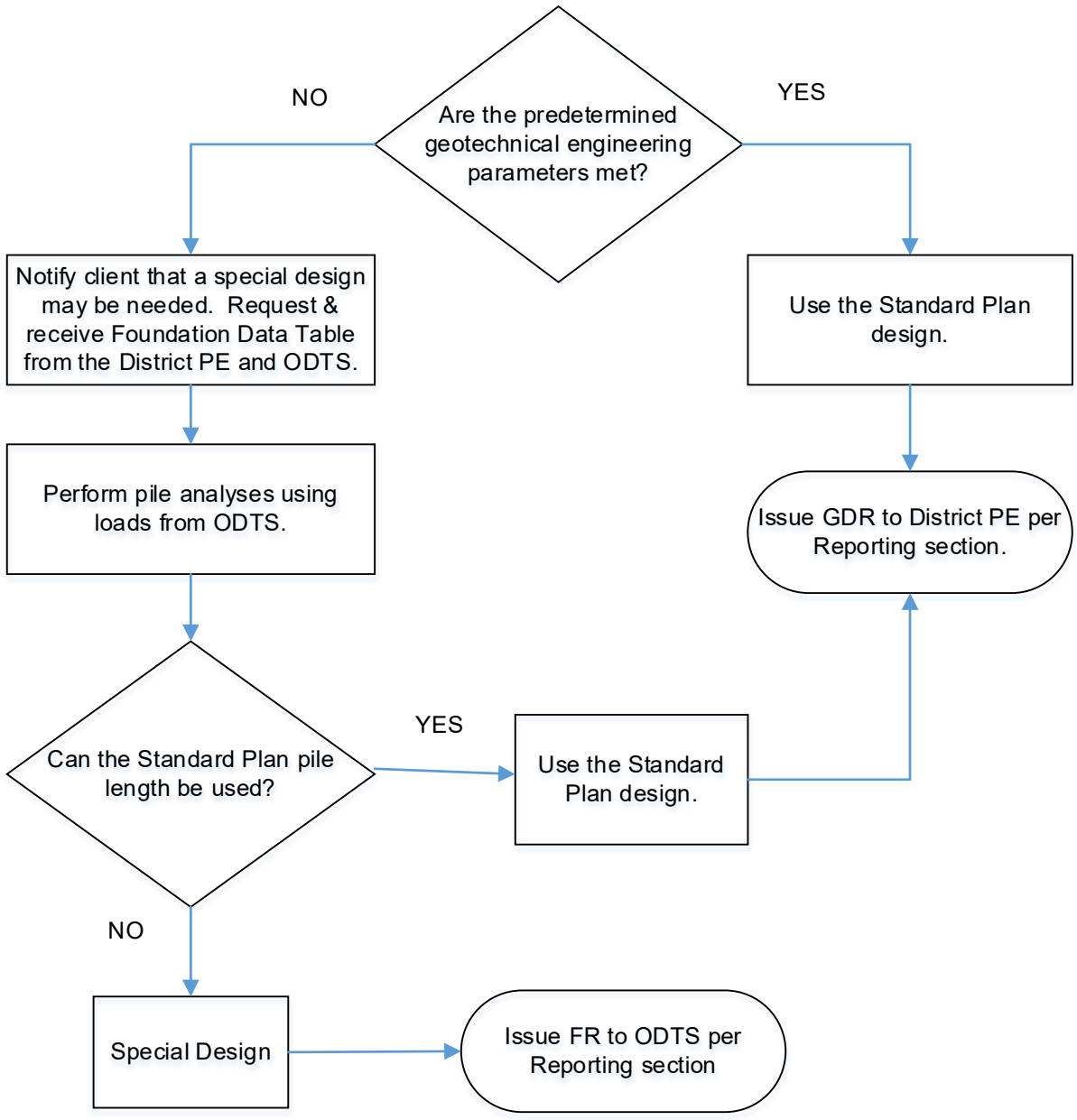
Sampling and testing should include the Standard Penetration Testing (SPT) and other relatively undisturbed sampling (if practical to obtain) of soils. Perform field pocket penetrometer or torvane tests on cohesive soils. Perform soil corrosion testing as specified in Section 7.1 of the *Corrosion Guidelines*.

Use the *Soil Correlations* module to determine soil strength and unit weight. Presenting the "soil identification" as determined by the *Soil and Rock Logging, Classification and Presentation Manual* is sufficient. Consider performing laboratory strength tests only when the field test results are limited, in question, or near to but less than the minimum strength requirements.

It is not necessary to conduct a drilling program for OH Signs or ES Poles that will be founded entirely in engineered fill that has yet to be placed, such as elevated roadway embankments or sliver widenings, as embankment fill placed to Caltrans Standard Specifications exceeds the minimum required soil strength.

Design

The design process is dictated by whether the Standard Plan design can be used, which depends on whether the geotechnical engineering parameters listed above meet their minimum requirements. The following flowchart shows both processes.



Standard Plans Design Parameters Are Met

CIDH pile foundations for OH Signs and ES Poles require a minimum friction angle (phi) of 30 degrees and a total unit weight of at least 120 pcf for cohesionless soils, or an undrained shear strength of 1.5 ksf for cohesive soils. OH Signs utilizing CIDH pile foundations can be placed in or near sloping ground as steep as 2H:1V. ES Poles utilizing CIDH pile foundations can be placed in or near sloping ground as steep as 2H:1V provided that the CIDH embedment depth is increased by one pile diameter when ES poles are placed in or near sloping ground between 4H:1V and 2H:1V (Std. Plan ES 11).

More detailed information on the predetermined geotechnical engineering parameters used to design foundations can be found on the Standard Plans or in the respective *User Guide to Standard Plans* (available from Structures and Engineering Services).

For materials placed in accordance with Caltrans Standard Specifications: Engineered fills compacted to 95% relative compaction (e.g., approach embankments within 150 feet of a bridge abutment) should be assumed to have a friction angle of at least 34 degrees and satisfy the requirements. Engineered fills compacted to 90% relative compaction (most fills other than abutment approach fills) should be assumed to have a friction angle of at least 30 degrees and satisfy the requirements.

There is no need to perform lateral, torsional, or axial resistance analyses if the minimum design requirements are met.

The Standard Plans show a spread footing option for OH Signs-Truss, Single Post and Two Post, OH Signs-Lightweight, and ES Pole-CCTV with VDS. In the case where a spread footing design is considered, contact the standard plan owner to obtain the loads and eccentricities, then analyze bearing capacity, and check it against the design criteria to verify the geotechnical design.

Seismic investigations are not necessary except to evaluate liquefaction potential. Seismic related soil strength loss and settlement of materials along the pile length may require a special design. If liquefaction is probable, contact the client and discuss whether to include recommendations for mitigation in the report.

OH Signs and/or ES Poles are sometimes added to a project by the District late in the PS&E process (after field investigations are completed and/or geotechnical reports have been completed). In these cases, the “Office Work” and “Site Investigation (Planning Phase)” of the *Geotechnical Investigations* module should be performed and expanded to include any recently acquired project specific subsurface data, followed by a no-drill option assessment.

Standard Plans Design Parameters Are Not Met

A design check is required when any of the predetermined geotechnical engineering parameters are not met. Obtain the Foundation Data Table (see Table 3) from the Office of Design and Technical Services (ODTS) and check the standard plan pile design for a lateral, torsional, and axial load demand of the standard plan pile to verify if the standard plan foundation is still sufficient.

To obtain the Foundation Data Table:

- Email ODTS and District Design to inform them of the potential need of a special design. Include the following in the email:
    - Request that ODTS provide a Foundation Data Table (i.e., design acceptance criteria and maximum reaction loads at top of pile, Table 3). Attach the ODTS Request Form (see attached example).
    - ODTS should be provided at least 4 weeks to provide the foundation data table
    - Request additional resources for GS and ODTS as appropriate from the District.

Table 3: Foundation Data Table

Sign/Pole Name	Sign/Pole Type	Pile Type	Maximum Reactions at Top of Pile (Unfactored)				Allowable Pile Head Deflection (in)	Allowable Pile Head Rotation (rad)
			Axial (kips)	Shear (Kips)	Bending (kip-ft)	Torsion (kip-ft)		
Space for entering sign/pole name	Space for entering sign/pole type	Space to enter pile type	Space to enter the Axial (kips) of maximum reactions at the top of pile (unfactored)	Space to enter the Shear (kips) of maximum reactions at the top of pile (unfactored)	Space to enter the Bending (kip-ft) of maximum reactions at the top of pile (unfactored)	Space to enter the Torson (kip-ft) of maximum reactions at the top of pile (unfactored)	Space for entering the allowable pile head deflection (in)	Space for entering the allowable pile head rotation (rad)

Use the information in the Foundation Data Table to perform the following analyses:

Lateral Resistance Analysis

For lateral analysis, use Allowable Stress Design (ASD) method to check:

- Allowable lateral pile head deflection and rotation using unfactored maximum reactions at top of pile.
- Calculated pile maximum moment and shear force using unfactored maximum reactions at top of pile.

Torsional Resistance Analysis

Use ASD method to check pile length for unfactored torsional reaction load. To calculate torsional resistance (*T*), use the following equations with a factor of safety of 1.5.

- Cohesionless Soil (Colorado Department Transportation Design Method, *Nusairat et al. 2004*)

$$T = T_s + T_t$$

$$r_s = K\sigma'_{vz}\, tan\delta$$

$$K = \frac{2L}{3D}(1 - sin\phi')$$

$$T_s = \frac{\pi D^2}{2} L\, r_s$$

$$T_t = \frac{D}{3} W\, tan\delta$$

Where T_s = side torsional resistance, T_t = toe torsional resistance, ϕ' = effective friction angle, σ'_{vz} = effective vertical stress at the mid-point of the layer of interest, δ = effective soil-pile interface friction angle, L = pile length, D = pile diameter, and W = pile weight.

- Cohesive Soil (Colorado Department Transportation Design Method, *Nusairat et al. 2004*)

$$T = T_s + T_t$$

$$T_s = \frac{\pi D^2}{2}(L - 1.5D)\, S_u$$

$$T_t = \frac{\pi D^3}{12} S_u$$

Where Su = undrained shear strength over the depth of interest.

Axial Resistance Analysis

Use ASD method to check pile length for unfactored axial load.

When evaluating the CIDH pile axial geotechnical capacity use the design method presented in the *Cast-in-Drilled-Hole (CIDH) Pile Foundations* module with a factor of safety of 2.0.

Recommend the Standard Plan foundation if the evaluation determines that the design requirements are met. If the Standard Plan foundation is found to be insufficient, a special design is required. Consider the following for design:

- Increase pile length and/or pile diameter: When the increased pile length does not satisfy the pile head deflection and rotation requirement, consult with the ODTS to increase the pile diameter.

Reporting

Standard OH Sign and ES Pole foundation recommendations are conveyed to the District in a Geotechnical Design Report (GDR). When a special design is required, prepare a Foundation Report (FR) in accordance with the *Foundation Reports for Bridges* module addressed to the Structure Designer in ODTS. Regardless of report type, the content should be brief and address the following:

- Location of the OH Sign/ES Pole
- OH Sign/ES Pole type
- Summary of investigation performed
- Soil description, strength, and unit weight
- Depth to groundwater
- Corrosion test results
- Discussion of liquefaction potential
- Foundation data tables from ODTS
- Recommended foundation type(s) and dimensions:
    - Pile length and diameter for CIDH piles including the adjustment for sloping ground if applicable.
    - Spread footing dimensions and bottom of footing elevation or depth of burial.
- Recommendation for wet CIDH construction methods if the proposed pile excavation extends below the groundwater level.

For a special design foundation, include the following table in addition to the Foundation Data Table (see Table 3)

Table 4: Foundation Recommendation Table

Sign/Pole Name	Sign/Pole Type	Pile Type					Pile Embedment Length (feet)		
			Axial (kips)	Shear (kip)	Bending (kip-ft)	Torsion (kip-ft)		Max. Moment (kip-ft)	Maximum Shear (kip)

A Log of Test Borings (LOTB) sheet or Boring Record (BR) must be produced if a boring was completed. When a standard design is recommended, attach a BR and As-built LOTB (if any) to the GDR. A LOTB is not required for the standard design and GDR unless the District requests. Produce a LOTB sheet and As-built LOTB sheet (if any) when a Foundation Report is completed. Add a note to the FR directing the designer to include the LOTB sheet in the contract plans, along with a list of LOTB sheet titles.

References

1. Caltrans (2017) "*User Guide to Standard Plans Section S – OVERHEAD SIGNS – TRUSS*", Office of Design and Technical Services, Caltrans Division of Engineering Services.
2. Caltrans (2021) "*User Guide to Standard Plans Section S – OVERHEAD SIGNS – VERSATILE TRUSS*", Office of Design and Technical Services, Caltrans Division of Engineering Services.
3. Caltrans (2017) "*User Guide to Standard Plans Section S – OVERHEAD SIGNS – TUBULAR*", Office of Design and Technical Services, Caltrans Division of Engineering Services.
4. Caltrans (2017) "*User Guide to Standard Plans Section ES – ELECTRICAL SYSTEMS – Poles, Posts, and Standards*", Office of Design and Technical Services, Caltrans Division of Engineering Services.
5. Caltrans (2017) "*User Guide to Standard Plans Section ES – TEMPOARY WOOD POLES*", Office of Design and Technical Services, Caltrans Division of Engineering Services.
6. J. Nusairat, R. Liang, R. Engel, D. Hanneman, N. AbuHejleh, and K. Yang (2004), *"Drilled Shaft Design for Sound Barrier Walls, Signs, and Signals."* Report No. CDOT-DTD-R-2004-8, Colorado Department of Transportation, Denver, CO.

Appendix A: Standard Plans OH and Pole Sheet Summary

OH Signs: Truss Single Post Types II through IX

Single post truss signs may be supported by either spread footings or CIDH piles. Spread footings use the footing dimensions as specified in the revised Standard Plan RSP S2. CIDH pile foundations use Standard Plan S8 for pile dimensions.

OH Signs: Truss Two Post Types I-S through VII-S

Two post truss signs may be supported by either spread footings or CIDH piles. Spread footings use the footing dimensions as specified in the Standard Plan S9. CIDH piles use Standard Plan S15 for pile lengths.

OH Signs: Tubular

Single post and two post tubular signs are supported by CIDH piles. See Standard Plan S36 and S37 for pile dimensions.

OH Signs: Lightweight Extinguishable Message Sign and Flashing Beacons

Lightweight Extinguishable Message Sign and Flashing Beacons may be supported by either spread footings or CIDH piles. Spread footings use the footing dimensions as specified in Standard Plan S49. CIDH pile foundations use Standard Plan S49 for pile dimensions.

OH Signs: Versatile Truss One Post Type

Single Post Versatile Truss signs are supported by CIDH piles. See Standard Plans RSP S104 and RSP S105 for CIDH pile details. See Standard Plan RSP S114 for CIDH inspection pipe details.

OH Signs: Versatile Truss Two Post Type

Two Post Versatile Truss signs are supported by CIDH piles. See Standard Plans RSP S109 and RSP S110 for CIDH pile details. See Standard Plan RSP S114 for CIDH inspection pipe details.

ES Poles: Electrical Systems - Lighting Standards

Lighting standards are supported by CIDH Piles. See Standard Plans RSP ES-6A, ES-6D, ES-6E and ES-6G for pile dimensions.

ES Poles: Electrical Systems – Signal and Lighting Standards

Signal and lighting standards are supported by CIDH Piles. See Standard Plans RSP ES-7A, RSP ES-7C, RSP ES-7D and RSP ES-7E, RSP ES-7F, RSP ES-7G, and RSP ES-7H for pile dimensions.

ES Poles: Electrical Systems – Flashing Beacons

Flashing Beacons are supported by CIDH Piles. See Standard Plans RSP ES-7J and ES-7K for pile dimensions.

ES Poles: Electrical Systems – CCTV Pole

CCTV Poles are supported by either spread footings or CIDH piles. CIDH piles use Standard Plans RSP ES-16B, RSP ES-16C and RSP ES-16D for pile dimensions. Spread footings use the footing dimensions as specified in the Standard Plan RSP ES-16D.

ES Poles: Electrical Systems – Pedestrian Barricades

Pedestrian barricades (guard posts and pedestrian barriers) are supported by concrete backfilled post holes. See Standard Plan ES-7Q for post hole dimensions.

ES Poles: Electrical Systems – Temporary Wood Poles

Temporary wood poles are supported by poles embedded in foundation holes backfilled with manufactured sand. See Standard Plans RSP ES-18B, RSP ES-18C, RSP ES-18D and RSP ES-18E for pole hole embedment depths. See the “Foundation Design Notes” on Standard Plan ES-18A for the assumed geotechnical engineering parameters foundation pressures.