Sound Walls (Standard Plan)

Sound wall foundation design consists of choosing standard designs from the current Standard Plans (2006 Standard Plan B15-1 to B15-15). The following foundation types may support standard sound walls:

- Pile Cap
- Trench Footing
- Spread Footing

Sound wall foundation types and sizes shown on the Standard Plan Sheets were designed using assumed soil strength parameters. The objective of a sound wall foundation investigation is to determine if the soil strength at the proposed wall location meets or exceeds the assumed soil strength used to design the sound wall.

Sound walls are not designed to retain soil. In cases where soil retention is necessary the sound wall may be constructed on a Type 736/SV Barrier, which allows retention of up to four feet of soil, or on a retaining wall. Standard Type 1, 5 and 7 retaining walls have been redesigned to accommodate sound walls and are available as Bridge Standard Details Sheets.

Typically, the most cost effective sound wall foundation is cast-in-drilled-hole (CIDH) piles. This is different from most structures where the least expensive foundation is usually spread footings. Trench footings may be considered where groundwater would require wet pile installation but the trench footing is dry. Maximum trench footing depth is less than 12 feet.

Investigations

Exploration for standard plan sound wall foundation design seeks to identify and describe the subsurface material, determine its strength, locate the water table (if within the depth of the anticipated sound wall foundations), and to identify relevant conditions that might affect the foundation construction, such as caving conditions, the presence of cobbles and boulders, or shallow rock.

Borings should be spaced no closer than 500 feet apart unless warranted by anticipated variations in soil strength parameters, constructability conditions and/or foundation types.

Borings for standard sound walls should extend no deeper than 25 feet below the proposed bottom of sound wall. The deepest foundation required for a standard sound wall is 16 feet and since overturning controls the foundation design, there is little reason

to consider drilling deeper. Deeper borings (max 30') may be needed for a sound wall on Type 736S/SV barrier on pile footing for spanning utilities.

Auger borings are preferred since they mimic the typical construction method for sound wall CIDH pile foundations. They provide information on hole stability, water table, and presence of cobbles and boulders or shallow rock, which might render CIDH piles infeasible.

Sampling and testing should be limited to Standard Penetration Testing (SPT) in granular soil or California Modified (push) sampling with field pocket penetrometer or torvane testing in cohesive soils.

As sound wall foundation design is based on constructability and three standard soil strength cases, laboratory testing should not be performed for the purposes of determining soil strength or *Soil Classification*. SPT, pocket penetrometer and torvane measurements are sufficient for correlating to soil strength. Presenting the *Soil Identification* as determined by the visual/manual method provides sufficient information for designing and constructing sound wall foundations. Corrosion testing is not required for standard plan sound walls.

It is not necessary to conduct a drilling program for sound walls that will be founded entirely in fill that has yet to be placed, such as elevated roadway embankments or sliver widenings, as fills are constructed to a minimum of 90% relative compaction.

Design Procedures for Sound Walls Supported on CIDH Piles and Trench Footings

The design of sound walls supported on CIDH piles and trench footing foundations are based on two parameters:

1. Ground line

   Case 1: Level ground ($\pm$ 10%) on both sides of the wall
   Case 2: Level ground ($\pm$ 10%) on the traffic side of the wall, sloping ground no steeper than 2:1 on the opposite side

2. Soil Friction Angle (ϕ)

   Phi = 25°
   Phi = 30°
   Phi = 35°

The soil friction angle (ϕ) may be determined by correlations with the SPT results as shown in Table 1.

Table 1: SPT and Friction Angle (ϕ)

Adjusted SPT, $(N_1)_{60}$*	Recommended Friction Angle, ϕ
$4 \leq (N_1)_{60} < 10$	25°
$10 \leq (N_1)_{60} < 26$	30°
$26 \leq (N_1)_{60}$	35°

*$(N_1)_{60}$ is the field SPT "N" value adjusted for hammer efficiency and normalized to 1 ton/ft^2 overburden pressure.

In cases where soils are predominantly cohesive, the unconfined compressive strength (q_u) or undrained shear strength (C_u) may be used to approximate an equivalent granular "N" value as follows:

$q_u = (N_1)_{60} \div 10$ where q_u is in tsf and N_1 is the Standard Penetration Test "N" value normalized to 1 ton/ft^2 overburden pressure

$C_u = (N_1)_{60} \div 20$ where C_u is in tsf, and N_1 is the Standard Penetration Test "N" value normalized to 1 ton/ft^2 overburden pressure

Table 2 presents the design friction angle in relation to the undrained shear strength.

Table 2: Undrained Shear Strength and Friction Angle

Undrained Shear Strength, C_u (tsf)	Friction Angle, ϕ
$0.25 \leq C_u < 0.5$	25°
$0.5 \leq C_u < 2.5$	30°
$2.5 \leq C_u$	35°

Engineered fills compacted to 95% relative compaction (e.g., approach fills within 150 ft of a bridge abutment~~s~~) should be assumed to satisfy the requirements for phi = 35°. Engineered fills compacted to 90% relative compaction (most fills other than abutment approach fills) should be assumed to satisfy the requirements for phi = 30°.

If the field investigation reveals that the CIDH piles would extend below the ground water surface, then CIDH piles should be abandoned as the preferred foundation type in favor of a trench or spread footing. If neither the trench or spread footing alternatives are feasible, then CIDH piles should be recommended provided that they are 24-inches in diameter to satisfy the requirement for non-destructive testing (gamma-gamma logging) of the piles. Recommending 24-inch CIDH piles for support of a sound wall will require a special design by Structures Design, so this alternative should be used only after the three standard foundation types are proven infeasible. The only standard plan sound wall design requiring 24-inch CIDH piles for support is for a wall spanning over buried utilities as shown on Standard plan sheet B15-15.

Design Procedures for Sound Walls Supported on Spread Footings

The design of standard plan sound walls supported on spread footing foundations is based on Working Stress Design and Allowable Soil Bearing pressures. The Standard Plans show two ground line cases as follows:

Case 1: Level ground (± 10%) on both sides of the wall
Case 2: Level ground (± 10%) on the traffic side of the wall, sloping ground no steeper than 2:1 on the opposite side

Table 3 presents the footing width (B), the reduced footing dimension (B'), the equivalent footing contact pressures ($q_{contact}$) and the required ultimate soil bearing capacity (q_{ult}) for the various sound wall heights. When recommending a sound wall to be supported on a spread footing, the geoprofessional must verify that the soil conditions at the wall location meet or exceed the required Ultimate Soil Bearing Capacity, q_{ult}.

Table 3: Spread Footings

Wall Height (H)	Footing Width (B)	Reduced Footing Dimension, (B')	Equivalent Uniform Footing Contact Pressure, ($q_{contact}$)	Required Ultimate Soil Bearing Capacity, (q_{ult})
6 ft	3 ft	1.1 ft	0.5 tsf	1.5 tsf
8 ft	4 ft	1.7 ft	0.3 tsf	0.9 tsf
10 ft	5 ft	2.7 ft	0.2 tsf	0.6 tsf
12 ft	5.75 ft	2.6 ft	0.2 tsf	0.6 tsf
14 ft	6.5 ft	2.9 ft	0.2 tsf	0.6 tsf
16 ft	7.5 ft	2.5 ft	0.2 tsf	0.6 tsf

Design Procedures for Sound Walls Supported on Retaining Walls on Spread Footings

For sound walls supported on retaining walls supported on spread footings, refer to the appropriate Bridge Standard Details "XS" sheets for the required ultimate soil bearing pressure, q_{ult}.

Helpful hints

- Standard sound wall pile is 16 inches in diameter. Maximum particle size for easy construction of a 16" CIDH pile is about 5". Soil conditions with cobbles larger than 5" may not be suitable for CIDH pile foundations.
- The maximum required ultimate soil bearing capacity of a standard plan sound wall spread footing is about 1.5 tsf. This is typically satisfied by an average $(N_1)_{60}$ value of 5 or larger within the depth B below the bottom of the proposed footing.

- If liquefaction is probable, the geotechnical designer should contact the client and discuss whether or not to include recommendations for mitigation in the report.
- Standard trench width for sound wall foundations is 12" (Case 1) or 15" (Case 2). Maximum particle size for construction of trench footings is about 6".
- Trench footings are not suitable foundation types in caving soils or below the water table.

Related Standards:

- Standard Plan Numbers B15-1 through B15-15
- Bridge Standard Details Sheets XS14-010 through XS14-410-2e.
- Bridge Memos to Designers 22-1
- Standard Specifications, 2006, Sections 6-3.01, 19-5.03 and 19-5.04

Reporting

Standard plan sound wall foundation recommendations must be conveyed to the client using the Geotechnical Design Report (GDR) format. The report should be brief and include a table presenting the following information:

- The beginning and ending stationing
- The wall height, H
- Recommended foundation type (e.g., CIDH piles, trench footing, or spread footing)
- Ground line Case condition, (Case 1 or Case 2)
- Soil strength, Phi value to be used for design, $\phi = 25°$, $\phi = 30°$ or $\phi = 35°$

A Log of Test Borings (LOTB) must be included with the design recommendations. A note should be added to the report directing the designer to include the LOTB in the contract plans, along with a list of LOTB sheet titles.

Table 4 presents example sound wall foundation recommendations. The following conditions exist at the site, which caused the designer to deviate from the preferred CIDH foundation type.

- From Station 16+27 SW LOL to Sta 20+37 SW LOL, shallow ground water exists.
- From Station 20+37 SW LOL to Sta 22+ 89 SW LOL shallow ground water and caving conditions exist.

Table 4: Sound Wall Foundation Recommendations

Wall Location	Wall Height (H)	Foundation Type	Ground line	Friction Angle (ϕ)
Sta 08+59 SW LOL to Sta 11+ 47 SW LOL	H = 12	CIDH Piles	Case 1	35°
Sta 11+47 SW LOL to Sta 12+89 SW LOL	H = 10	CIDH Piles	Case 2	35°
Sta 15+17 SW LOL to Sta 16+ 27 SW LOL	H = 10	CIDH Piles	Case 2	35°
Sta 16+27 SW LOL to Sta 20+37 SW LOL	H = 10	Trench Footing	Case 1	30°
Sta 20+37 SW LOL to Sta 22+ 89 SW LOL	H = 12	Spread Footing	Case 1	N/A