Seal Course

A seal course is a layer of concrete placed in an excavation for the purpose of preventing groundwater infiltration. Use of a seal course with cofferdams allows the footing reinforcement and concrete to be placed under dry conditions. Seal courses can be used for both shallow and deep foundation (e.g., pile cap, CISS) construction. See Caltrans Bridge Design Memo 10.3 and Foundation Manual 12-3 and 12-4 for more details. This module provides an overview of structure excavation as it relates to seal course and guidance on how to calculate a seal course thickness.

For a shallow foundation, the seal course thickness is a function of the hydrostatic pressure at the bottom of seal course (i.e., bottom of excavation). The hydrostatic pressure is dependent on the hydrostatic head (feet), which is the distance from the bottom of excavation elevation to the highest anticipated groundwater elevation surrounding the footing excavation.

For a pile cap, the seal course thickness is a function of the hydrostatic pressure at the bottom of seal course (i.e., bottom of excavation), the bond strength between the piles and seal course concrete, and the capacity of the piles in tension. Use 10 psi for the pile/concrete bond strength.

For a deep foundation, the seal course thickness is a function of the hydrostatic pressure at the bottom of seal course (i.e., bottom of excavation), the bond strength between the concrete and pile, and the dimensions of the pile and pile footing. Use 2 psi for the pile/concrete bond strength to account for the difficulty in cleaning the CISS pile. An example seal course calculation for a CISS foundation is presented in the *Driven Pile Foundations* module, Appendix C.

In all cases, the minimum seal course thickness is 2 feet.

If groundwater levels are expected to be above the bottom of footing/pile cap elevation, and it is anticipated that the groundwater cannot be controlled with pumps or barriers, a seal course will be required, and Structure Excavation (Type A) must be discussed in the Preliminary Foundation Report and again in the Foundation Report. If it is anticipated that Structure Excavation (Type A) is needed, then discuss with the Bridge Designer and Structures Construction personnel before finalizing the Preliminary Foundation Report. For Structure Excavation (Type A), the seal course thickness must be calculated and reported.

If groundwater levels are anticipated to be near the bottom of footing/pile cap elevations, then use of seal course is optional, and Structure Excavation (Type D) should be discussed in the Preliminary Foundation Report and Foundation Report. Structure Excavation (Type D) will allow the contractor flexibility in finding the most cost-effective method for dewatering the excavation (e.g., sump pump). For Structure Excavation (Type

D), the seal course thickness is not calculated. See Bridge Design Aids, Section 11 (Estimating) for more details.

Shallow Foundation

Use the following equation to calculate the seal course thickness.

Seal course thickness (feet), $t \geq \frac{(\text{hydrostatic head})(62.4 \text{ pcf})}{145 \text{ pcf}}$

Where: $\gamma_{concrete} = 145\ pcf$

$t \geq (0.43)(\text{hydrostatic head})$

Pile Cap Foundation

The uplift buoyancy force acting on the seal course must be less than the weight of seal course concrete and the frictional resistance between the piles and seal course concrete. An additional one foot of seal is provided to allow for irregularity between the top and bottom surfaces.

Uplift buoyancy force ≤ Total uplift resistance

$$(\text{hydrostatic head})\ (\gamma_w)(A_f - a_p) \leq \left[\gamma_c(A_f - a_p) + \tau(p)\right](t-1)$$

$$t \geq \frac{(\text{hydrostatic head})(\gamma_w)(A_f - a_p)}{\gamma_c(A_f - a_p) + \tau(p)} + 1$$

Where:

t = seal course thickness (feet)

γ_w = unit weight of water = 62.4 pcf

A_f = Tributary area (ft^2) of footing for a single pile = S_1^2 (for square spacing) or $S_1 * S_2$ (for rectangular spacing), or S_1 * Footing Width (for a single pile row)

S_1, S_2 = center-to-center pile spacing in each direction (feet)

a_p = Pile cross sectional area = πr^2 (circular pile) or d^2 (square pile)

r = pile radius (feet)

d = pile side length (feet)

For other pile types (e.g., H-Pile), refer to the manufacturer's specifications for a_p

γ_c = unit weight of concrete = 145 pcf

τ = bond strength between the pile (steel or concrete) and seal course concrete (for pile cap use 10 psi = 1440 psf)

p = perimeter of pile = $2\pi r$ (circular pile) = 4d (square pile)

Example 1: Seal Course Thickness Calculation with Given Hydrostatic Head

Assume:

- 14-inch square reinforced concrete piles
- Pile spacing: S_1 = 3.5 feet by S_2 = 4.0 feet
- Hydrostatic head = 15.0 feet
- Bond strength between pile and seal course concrete = 1440 psf

Tributary Area (A_f) = S_1*S_2 = 3.5*4.0 = 14 ft^2

Pile Area (a_p) = d^2 = $\left(\frac{14}{12}\right)^2 = 1.36$ ft^2

Pile Perimeter (p) = 4d = $4\left(\frac{14}{12}\right) = 4.67$ feet

Seal course thickness is calculated as follows:

$$t \geq \frac{(\text{hydrostatic head})(\gamma_w)(A_f - a_p)}{\gamma_c(A_f - a_p) + \tau(p)} + 1$$

$$t \geq \frac{(15)(62.4)(14 - 1.36)}{(145)(14 - 1.36) + (1440)(4.67)} + 1$$

t ≥ 2.38 feet say 2.5 feet (exceeds 2-foot minimum) OK

Calculate the tension load demand (bond strength) per pile:

$\left(1440\frac{lb}{ft^2}\right)(4.67\ ft)(2.5\ ft) = 16800$ pounds = 16.8 kip

Calculate the nominal tension resistance per pile and verify that it is greater than 16.8 kips.

Example 2 – Seal Course Thickness Calculation as a Function of Hydrostatic Head

Assume:

- 12-inch diameter steel pipe piles
- Pile spacing: S_1 = 3.0 feet center-to-center both directions
- Bond strength between steel pile and seal course concrete = 1440 psf

Tributary Area (A_f) = S_1^2 = 9 ft^2

Pile Area (a_p) = $\pi r^2 = \pi(0.5)^2 = 0.785$ ft^2

Pile Perimeter (p) = $2\pi r = 2\pi(0.5) = \pi$

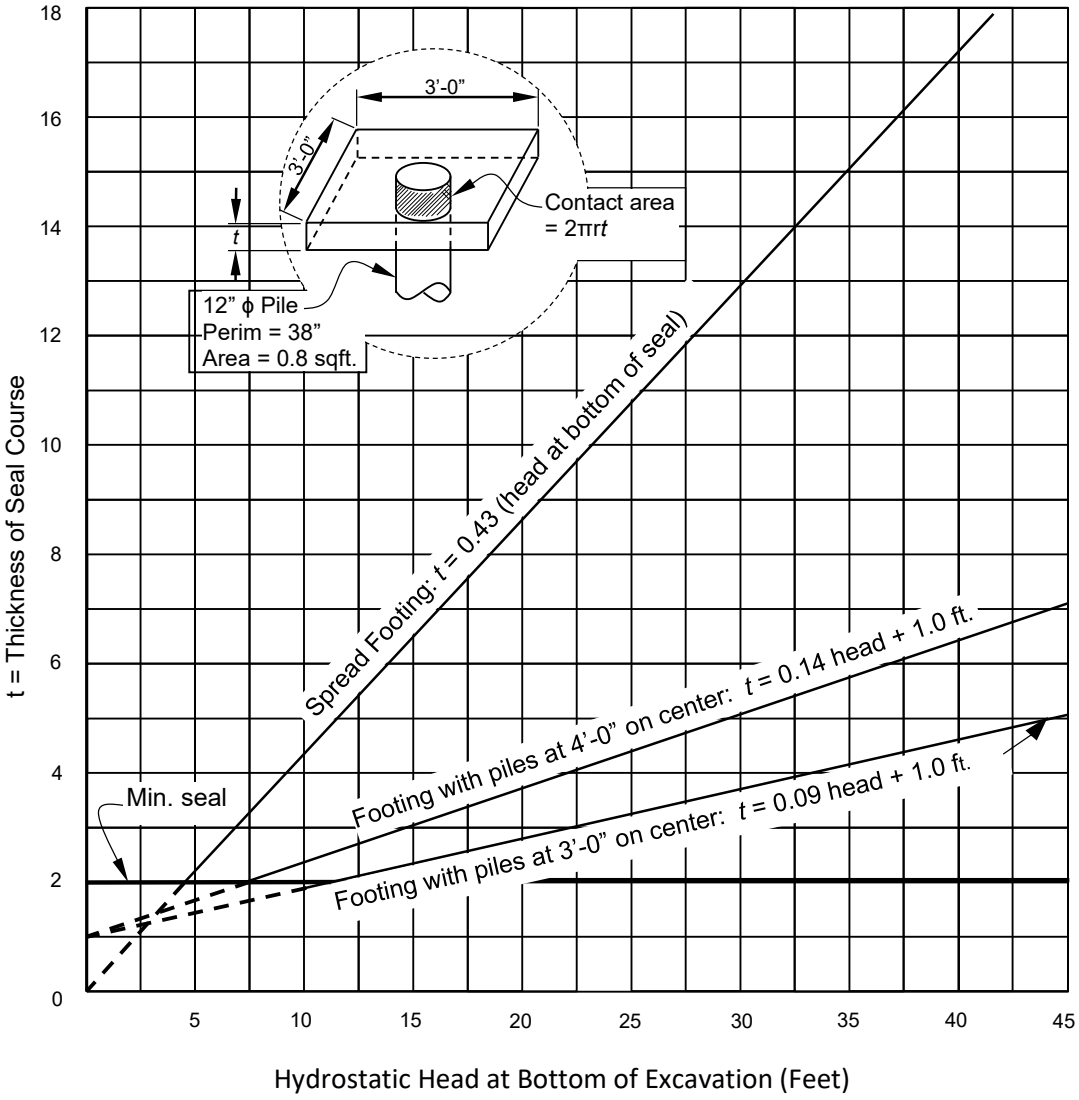
Seal course thickness is calculated as follows:

$$t \geq \frac{(\text{hydrostatic head})(\gamma_w)(A_f - a_p)}{\gamma_c(A_f - a_p) + \tau(p)} + 1$$

$$t \geq \frac{(\text{hydrostatic head})(62.4)(3^2 - 0.785)}{(145)(3^2 - 0.785) + 1440(\pi)} + 1$$

$$t \geq (0.09)(\text{hydrostatic head}) + 1$$

The following graph presents the seal course thickness as a function of hydrostatic head for a spread footing, and a pile cap with center-to-center pile spacings of 3 feet and 4 feet. The graph shows the requirement for a minimum thickness of 2 feet by using dotted lines for calculated thicknesses of less than 2 feet.



Seal Course Thickness for Spread Footing and Pile Cap Foundations

Reporting

Reporting specifics for seal course and Structure Excavation are presented in the *Foundation Reports for Bridges* module.

Additional Resources

- Geotechnical Manual - Driven Pile Foundations, Appendix C
- Bridge Construction Records and Procedures Manual (Vol. 2)
- Foundation Manual Section 12-3 and 12-4
- Bridge Design Memo 10.3
- Bridge Design Aids, Section 11 (Estimating)
- Standard Specifications, Section 51-1.03D(3) and SS, Section 51-1.10, Concrete Placed Under Water
- Standard Specifications, Section 19-3.04, Payment