Design Of Sheet Pile Walls

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Module 1: Design Fundamentals

Learning Objectives

By the end of this section, you will be able to:

- **Identify** the fundamental differences between cantilever, anchored, and I-wall configurations.
- **Select** appropriate analytical software tools based on the required design complexity (Classical vs. SSI).
- **Evaluate** the critical terminology and limit states used in sheet pile wall stability analysis.

Executive Summary: This course establishes the engineering standards for the safe and economical design of sheet pile retaining walls and floodwalls, prioritizing classical design procedures and soil-structure interaction for static loading environments.

Purpose

The primary objective of this course is to provide guidance for the safe design and economical **construction** of sheet pile retaining walls and floodwalls. While specific methods are outlined herein, PEs may utilize alternative analytical methods provided they maintain an equivalent degree of safety and economic efficiency.

Applicability

This guidance is mandatory for all design elements and field operating activities with civil works responsibilities.

References and Analytical Tools

Technical references and bibliographical materials supporting these standards are located in Appendix A.

Software Integration

To facilitate complex analytical functions, two primary computer programs are utilized:

- **CWALSHT (Program X0031):** Used for classical design and analysis. It determines the required depth of penetration and factors of safety, including the application of Rowe's Moment **Reduction** for anchored walls.
- **CWALSSI:** Used specifically for soil-structure interaction (SSI) analysis of both cantilever and anchored wall systems.

Design Scope

This guidance applies to wall/soil systems of traditional heights and configurations under static loading.

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⚠️ **Safety Constraint:** If a system must withstand earthquake effects or seismic loading as part of its design function, the design must conform to specialized industry standards and seismic requirements beyond the scope of this general manual.

Technical Definitions and Terminology

To ensure precision in design communication, the following terms are defined:

Wall Types and Systems

- **Sheet Pile Wall:** A row of interlocking vertical pile segments. Behavior is analyzed based on a typical 1-foot vertical slice.
- **Cantilever Wall:** Support is derived solely through interaction with the surrounding soil.
- **Anchored Wall:** Support is derived from a combination of soil interaction and mechanical devices. Note: This course is limited to single-level anchorage.
- **I-Wall:** A hybrid cantilevered wall using sheet piling for the embedded depth and a monolithic concrete wall for the exposed height.
- **Floodwall:** A wall designed primarily to sustain a difference in water elevation.
- **Retaining Wall:** A wall designed primarily to sustain a difference in soil elevation.

Site and Component Geometry

- **Retained Side (Backfill):** The side with the higher soil or water elevation.
- **Dredge Side (Dredge Line):** The side with the lower soil or water elevation; the "dredge line" refers to the soil surface on this side.
- **Wall Height:** The length of the piling above the dredge line.
- **Penetration:** The depth of the piling below the dredge line.

Anchorage Components

- **Anchors:** Structures that generate required force by interacting with soil or rock.
- **Tie Rods:** Parallel bars/tendons transferring force from the anchor to the wales.
- **Wales:** Horizontal beams attached to the wall to transfer tie rod forces to the sheet piling.

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Pressure and Stability

- **Active Pressure:** Soil pressure when the wall moves away from the soil, allowing horizontal expansion.
- **Passive Pressure:** Soil pressure when the wall moves **into** the soil, causing horizontal compression.
- **At-Rest Pressure:** Horizontal pressure when no deformation occurs.

🧮 **Calculation Note:** Factors of Safety (FSP) must be applied differently depending on the context:

1. **Rotational Failure:** Ratio of available resisting effort to driving effort.
2. **Soil Strength:** A strength reduction factor applied to soil parameters in Classical Design.
3. **Structural Material:** Ratio of limiting stress (yield) to calculated stress.

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Checkpoint Quiz

1. **A sheet pile wall that uses a single level of mechanical tie-backs to supplement soil resistance is classified as:**
    a) A cantilever wall
    b) An I-wall
    c) An anchored wall
    d) A gravity wall

Answer: (c). By definition, anchored walls use mechanical devices to inhibit motion.

2. **In Classical Design Procedures, how is "Penetration" defined?**
    a) The total length of the sheet pile segment.
    b) The depth of the piling driven below the dredge line.
    c) The distance from the top of the wall to the anchor level.
    d) The thickness of the concrete cap on an I-wall.

Answer: (b). This is the critical depth for establishing stability.

3. **Which software tool should a PE use specifically for Soil-Structure Interaction (SSI) analysis?**
    a) CWALSHT
    b) CWALSSI
    c) ASTM A-690
    d) Rowe's Moment Reduction Tool

Answer: (b). While CWALSHT handles classical techniques, CWALSSI is designed for SSI analysis.

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Module 2: General Considerations

Learning Objectives

By the end of this section, you will be able to:

- **Evaluate** alternative wall alignments based on site obstructions, environmental impact, and right-of-way constraints.
- **Select** the appropriate sheet pile material (Steel, Concrete, Aluminum, etc.) based on site conditions and structural requirements.
- **Differentiate** between cantilever and anchored wall applications regarding height limitations and proximity to existing structures.

Executive Summary: Successful sheet pile design requires continuous interdisciplinary coordination and a selection process that balances functional requirements (height and load) with geotechnical constraints and material durability.

Design Coordination

Coordination among hydraulic, geotechnical, and structural engineers must be continuous from project inception to operation. These disciplines must:

- Identify real estate requirements and alternative alignments.
- Determine effects on existing facilities and the environment.
- Consult with local interests who share costs and manage rights-of-way, relocations, and long-term maintenance.
- Conduct visual inspections throughout all project phases.

Alignment Selection

Alignment is often dictated by water sources (harbors/ports) or tie-ins to primary structures (locks/dams). The final alignment must compromise between economy and minimal environmental impact.

Key Alignment Factors

- **Obstructions:** Identify underground utilities (sewers, water, power) early. Undiscovered obstructions cause delays. In congested areas, consider requiring a contractor inspection trench prior to pile driving.
- **Impacts:** Alignments requiring permanent relocation of businesses or residences are rarely cost-effective. For floodwalls, provide gated openings for waterfront access.

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Purchase this course to see the remainder of the technical materials.