

## Chapter 30

### Retaining Walls

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## Chapter 30

# Retaining Walls

### 30.1 Purpose

The purpose of this chapter is to give the designer an understanding of the procedure to develop retaining wall plans. A step-by-step method to develop and organize the retaining wall plans is presented. An example of retaining wall plans is included. This chapter should be used in conjunction with the ***Structures Design Guidelines (SDG)***.

If the difference in height between the ground levels to be supported is 5 ft. or less, a gravity retaining wall is generally the most efficient structure to be used. For details of gravity retaining walls see the ***Design Standards, Index No. 520***.

When the difference in height between the ground levels to be supported exceeds 5 ft., then either a reinforced cast-in-place (C.I.P.) concrete cantilever retaining wall or a proprietary retaining wall is required.

Roadside barriers are generally required to shield vertical drop-offs created by retaining walls in fill sections. See ***Chapter 4*** of this volume for guidance on roadside barrier requirements.

Handrails or fences for bicyclists and pedestrians are also generally required when retaining walls are located within the right of way. This requirement must be addressed for retaining walls in fill sections as well as at the top of retaining walls in cut sections. In cut sections, the character and use of the adjoining property shall be considered when selecting the type of protection required. See ***Chapter 8*** of this volume for pedestrian and bicycle rail requirements.

In general, proprietary retaining walls should be utilized for projects when the exposed surface area of the walls exceed 1000 square ft. and sufficient room for the earth reinforcement system is available; however, site specific conditions must always be considered when determining the type(s) of wall to be designed. Proprietary precast walls other than MSE walls should be used as an alternate to C.I.P. walls when sufficient room for soil reinforcement is not available.

The following sections refer to the structures submittal procedure. For projects where there are no bridges, the roadway designer shall adjust the procedure as required for the roadway project.

## 30.2 Conventional (C.I.P.) Retaining Walls and Proprietary Retaining Walls (Permanent Walls)

The Department's policy is to provide either a set of conventional retaining wall plans or the "preapproved standard details" for all the proprietary walls that are technically appropriate for the site for all projects where walls are not supported on piles. Projects where walls are supported on piles only require a conventional pile supported wall design or a pile supported proprietary wall design. Omission of conventional retaining walls is possible if adequate justification is provided.

Proprietary retaining wall design plans are not required in the contract plans for normal uncomplicated wall projects. If the proprietary walls are experimental, exceed 40 ft. in height, are subject to unusual geometric or topographic features or, by the geotechnical report, will be subjected to excessive settlement, or environmental conditions, they may be required to have fully detailed design plans in the contract set.

The success of this method of producing and letting wall plans is highly dependent on complete, accurate and informative Control Plans. The importance of the Geotechnical Engineer's role in this scheme cannot be emphasized enough and shall include the following responsibilities:

1. Borings.
2. Soils Report.
3. Wall Type recommendation.
4. For Proprietary Walls: external stability analysis, minimum soil reinforcement length vs. wall height for external stability, maximum bearing pressure for each wall height and soil reinforcement length for each different wall height (1.5 ft. increments).
5. Review of internal stability design as provided by the wall companies.
6. Establishment of allowable bearing pressures.

The normal failure modes to be investigated are shown in **SDG, Figure 3-1**.

Step-by-step procedures for developing retaining wall plans follow.

## 30.2.1 Retaining Walls (Conventional Design)

### 1. Bridge Development Report (BDR) / 30% Plans

The BDR shall discuss and justify the use/non-use of conventional retaining walls. If the use of conventional retaining walls is applicable to the site and economically justified, it may be the only design required or it may be an alternate to a proprietary design. The 30% Plans submittal shall contain a location plan, plan and elevation of walls showing vertical and horizontal alignment, cross sections and details. The plans shall denote location of drainage inlets, utilities, sign structures, lights and barrier joints. Specifically the submittal package shall include:

#### a. Plan:

A plan view of the wall and footings which indicate pertinent dimensions, boring locations and horizontal alignment.

#### b. Elevation:

A front view of the wall which indicates pertinent dimensions and elevations, sign and lighting structures locations, drainage structure locations and flow line elevations, location of section views and vertical alignment.

#### c. Sections:

Sections taken through the wall to better indicate dimensions and elevations.

#### d. General Notes including:

- 1) Design Toe Pressure
- 2) Environmental Classification
- 3) Concrete - (Strength and Class)
- 4) Reinforcing Steel - (Grade)
- 5) Design Method
- 6) Soil Design Parameters for both the in situ and backfill materials
- 7) Load and Resistance Factors

### 2. 30% Plans:

The 30% Plans shall be submitted for approval and development of the plans continued towards the 90% Plans submittal.

### 3. 90% Plans:

The 90% Plans submittal shall be further developed to include, in addition to the information required for the 30% Plans, the following:

- a. Plan:  
A plan view of the wall and footings which indicates pertinent dimensions; reinforcing steel locations, cover and spacing in footings; and boring locations, back of wall drainage details and horizontal alignment.
- b. Elevation:  
A front view of the wall which indicates pertinent dimensions and elevations; location of section views; reinforcing steel location, cover and spacing; back of wall drainage and flow lines; vertical alignment; and locations of construction and expansion joints.
- c. Sections:  
Sections taken through the wall to better indicate dimensions, reinforcing steel locations, concrete cover for rebars and elevations.
- d. Estimated Quantities:  
Estimated quantities for items incorporated in the wall, reinforcing bar list and standard bar bending sheet.

The Structures Design Office has prepared ***Index No. 5100*** of the ***Design Standards*** for use in conventional cantilever retaining wall designs. This Design Standard is to be used in conjunction with the Retaining Wall computer program available on the Structures Design Office web site. Design assumptions used in the development of ***Index No. 5100*** are in the "Retaining Wall Notes" in the program.

## **30.2.2 Retaining Walls (Proprietary Design) (Design Required in Contract Plans)**

The following procedure for plans preparation should be followed if the walls are required to be fully detailed in the contract plans.

### **1. BDR/30% Plans**

The BDR shall discuss and justify the use of proprietary retaining walls. The 30% Plans shall contain preliminary Control Plans. It will not be necessary for these Plans to contain pay items and standard drawings; however, they shall include, but not be limited to, the following information:

- a. Key Sheet
- b. General Notes Sheet
  - 1) General notes
  - 2) In situ soil characteristics
  - 3) Design parameters
  - 4) Applicable wall systems
- c. Plan and Elevation Sheet:
  - 1) Horizontal and vertical alignment
  - 2) Limits of wall
  - 3) Utility locations
  - 4) Plan view of wall
  - 5) Elevation view of wall (showing existing and proposed ground lines, elevations at 30 ft. intervals at top of wall, wall embedment (maximum elevation at top of leveling pad) and beginning and end of wall stations)
  - 6) Boring locations
  - 7) Quantity (pay area of walls)
  - 8) Table showing soil reinforcement length vs. wall height (for external stability)
  - 9) Design parameters - Load and Resistance Factors
  - 10) Sections thru wall showing offset control point, pay area, ditches, sidewalks, superelevation and other unusual features

- 11) Ranges of wall systems applicable to the portion of the project defined by the plan and elevation sheet.
  - d. Soil Profile Sheet
  - e. General Details showing:
    - 1) Wall/end bent cap interface
    - 2) Barrier and coping to wall interface
    - 3) Pile, inlets and pipe conflicts with soil reinforcement and slip joint details
  - f. Preapproved Standard Drawings:

Note: Through the June 2006 letting, standard drawings for each of the alternate companies will be included in the **Design Standards**. As of the July 2006 letting, only general notes and common details for the proprietary retaining wall systems will be included in the **Design Standards**. Vendor drawings with wall specific details for each approved wall company will be relocated on the State Specifications Office QPL website.
2. Control Plans/Invitation Package

The Control Plans shall be reviewed by the Department and, upon approval, sent to all the appropriate wall companies. The companies shall be provided with a set of control plans, roadway plans and foundation report. The Control Plans shall be sent to the wall companies as soon as they are approved. This action shall be accomplished as soon as possible but not later than the 60% Plans. A copy of the transmittals to the wall companies shall be sent to the DSDO or SDO as appropriate. The proprietary companies shall acknowledge receipt of the invitation package. If they choose to participate they shall provide design plans for the retaining walls and submit the plans for review as prescribed in the invitation letter.
  3. 90% Plans

Upon receipt of the proprietary design plans, the designer shall review the design and incorporate the wall plans into the contract set. The plans from the wall companies, control plans and wall company standard drawings shall constitute the 100% Plans.



### 30.2.3 Retaining Walls (Proprietary Design - Control Plans only; Full Design not Required in Contract Plans)

Use the following procedure in preparing plans for wall projects.

1. BDR/30% Plans

Discuss and justify the use of proprietary retaining walls and FDOT Wall Types (see **Index 5300**) in the BDR. Provide documentation of all the site-specific geotechnical information and wall system considerations in the Retaining Wall Justification portion of the BDR. Include the Retaining Wall System Data Tables and Preliminary Control Plans with the information shown in **Section 30.2.2** for the Plan and Elevation Sheets.

2. 90% Plans

Include the Control Plans into the 90% Plans submittal.

General notes, common details, and the Table of FDOT Wall Types are shown in the **Design Standards**. Approved proprietary retaining wall system drawings and details are listed, with FDOT Wall Type, on the State Specifications Office QPL website. The Data Tables are available on the Structures FDOT CADD Menu cells.

The site-specific wall design details are submitted as shop drawings for each project.

## 30.2.4 Wall System Selection

Using the site-specific geotechnical information, the Engineer of Record (EOR), in cooperation with the geotechnical engineer, will determine all wall system requirements. Design considerations include short term and/or long term settlement, differential settlement (both longitudinal and from front of wall to end of concrete stems or soil reinforcement (rotation)), and global stability. Use the Flow Chart **Exhibit 30-A** for Permanent Retaining Wall Design to determine:

1. Plan requirements
2. Concrete Class, Concrete Cover, and FDOT Wall Type

For all walls, place notes on the General Notes sheet of the Control Plans in accordance with the Plan Requirements listed in the Flow Chart **Exhibit 30-A**.

During construction on projects with a FDOT Wall Type listed in the plans, the contractor will submit, for approval by the engineer, a QPL approved wall system allowed in accordance with FDOT Wall Type Table. The July 2006 **FDOT Standard Specifications Section 548, Retaining Wall Systems** will state: Unless otherwise detailed and/or shown in the plans, choose a wall system from the Qualified Products List (QPL) in accordance with the FDOT Wall Type listed in the plans.

On projects with non-QPL Walls (non-proprietary walls, complex walls, two phase walls, total settlement > 6 inches, differential settlement > 0.5%, etc), the complete wall design and details are included in the plans.

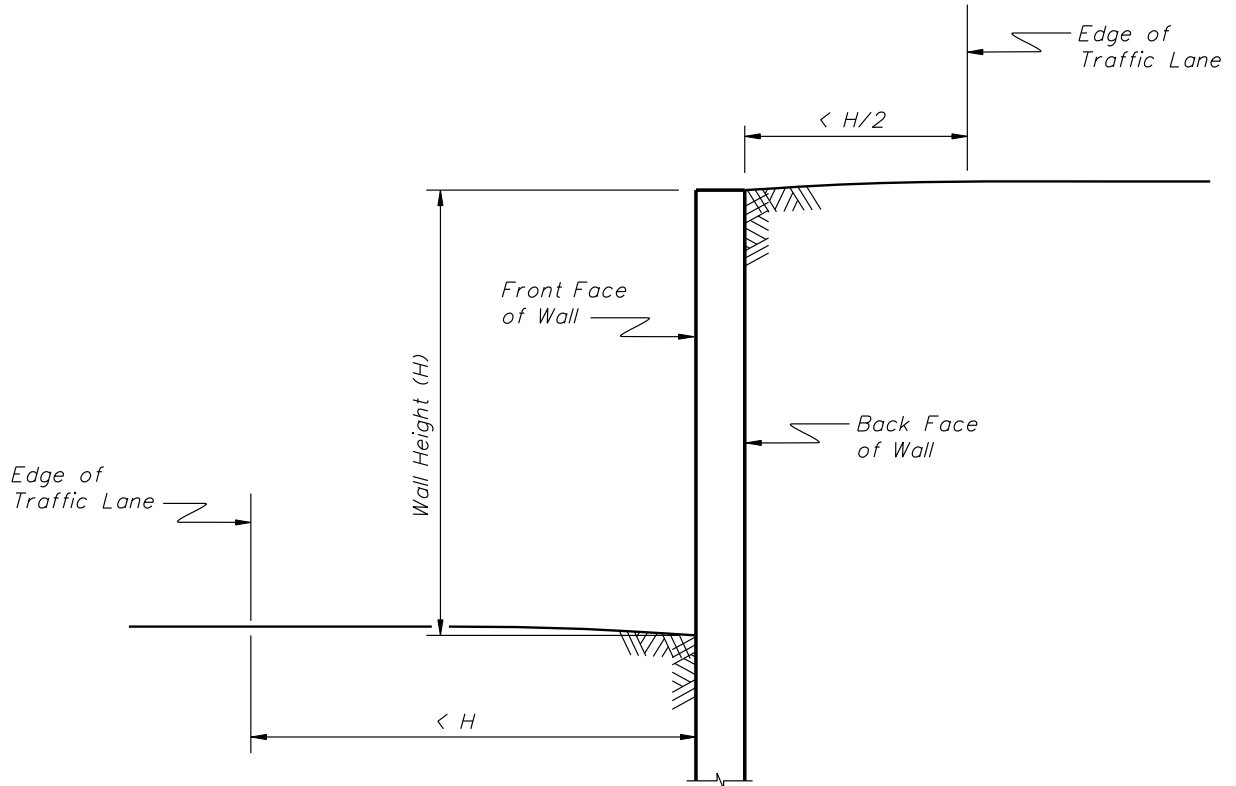
### 30.3 Critical Temporary Walls

A critical temporary wall is one that is necessary to maintain the safety of the traveling public, or structural integrity of nearby structures and utilities for the duration of the construction contract. Traffic lanes located either above or below a grade separation and within the limits shown in **Figure 30.1**, will require the design of a critical temporary wall. Critical temporary walls shall be designed in accordance with this chapter, the **AASHTO LRFD Bridge Design Specifications**, and the **Structures Design Guidelines**. Generally temporary walls should be either mechanically stabilized earth (MSE) walls or steel sheet pile walls.

Critical temporary proprietary MSE walls shall comply with **Design Standard Index No. 5301** and require generic design details in the contract plans. The plans format shall be in accordance with **Section 30.2.2** and **30.2.3**. Include control drawings and the completed Temporary Retaining Wall System Data Tables (See Structures FDOT CADD Menu cell). The final design details shall be submitted in the shop drawings.

Critical temporary sheet pile walls require complete design details in the contract plans. Include control drawings or tables with wall limits, minimum section modulus per foot, minimum moment of inertia per foot, minimum material properties, and minimum tip elevations. Provide a construction sequence and appropriate details if tiebacks are required, including anchors, wales, and deadmen or pullout resistance for grouted anchors.

**Figure 30.1 Location of Critical Temporary Wall with Respect to Traffic Lanes**



## 30.4 Experimental Wall Projects

Proprietary wall companies must comply with the Department's ***Guidelines for Selection and Approval of Proprietary Retaining Wall Systems, Topic No. 625-A20-118*** (available in Central Office Structures Design) and prepare standards to be approved and adopted by the FDOT. One of the requirements is to build a wall that may, at the discretion of the Department, be instrumented and monitored. Special instruction for design and plans preparation shall be obtained from the State Structures Design Office.

## 30.5 Shop Drawing Review

Conventional C.I.P. retaining walls do not require shop drawings; however, proprietary retaining walls require shop drawings in accordance with **Chapter 28**.

The shop drawing reviewer (EOR) shall be experienced in the requirements, design and detailing of proprietary wall plans. The EOR shall review but not be limited to the following items:

1. Verify vertical and horizontal geometry with contract plans.
2. Verify details with MSE wall suppliers standard details in contract plans.
3. Soil reinforcement placement in acute corners shall be detailed.
4. Slip joints shall be at all bin wall and standard MSE wall interface locations.
5. Soil reinforcement shall be detailed at all obstructions. Cutting or kinking of soil reinforcement shall not be allowed. Connection of soil reinforcement to piles or bearing against piles shall not be allowed.
6. Corner panels shall be used at all locations where walls are deflected horizontally 5 degrees or more.
7. Compare proposed reinforced fill characteristics with design fill characteristics. In-place moist density of backfill may vary by  $\pm 5$  pcf, and the internal friction angle may be  $1^\circ$  less than the design values (as shown in control plans) before a check of the wall design is required. If the internal friction angle is greater than the design value then a redesign is not required.
8. Review proprietary wall internal stability design calculations.
9. Verify soil reinforcement lengths for conformance to the **Structures Design Guidelines**, the external stability table on the plans, and the internal stability design calculations.
10. Confirm wall embedment.
11. Verify panel types and thickness are consistent with contract plans.
12. Soil reinforcement lengths shall be the same from top to bottom of wall at any section. The diameters of the longitudinal and transverse bars of any given mesh reinforcement shall be equal. The cross section of any soil reinforcement shall not vary along its length (i.e., "2WII" reinforcement shall not be spliced to "4WII").
13. Check stress level in soil reinforcement and connections.

14. Check steel strap soil reinforcement and consider the following for long straps:
  - a. One splice shall be permitted for steel strap soil reinforcement in excess of 32 feet in length.
  - b. Splice connection shall be Bearing-Type connections designed in accordance with the latest **AASHTO LRFD Bridge Design Specifications**.
  - c. Bolts shall be hot-dip galvanized ASTM A325 with appropriate washer and nut.
  - d. Corrosion rates for connections shall be in accordance with **Structures Design Guidelines Section 3.13.2-J**.
  - e. Holes shall be punched or drilled before galvanizing.
  - f. Strap extension shall be greater than  $\frac{1}{4}$  of the total strap length.

## **30.6 Bidding Procedure**

The conventional C.I.P. walls shall be bid as Concrete (Retaining Wall) and Reinforcing Steel (Retaining Wall). Conventional walls may be bid as an alternate to proprietary walls if the site conditions justify conventional walls.

Proprietary Walls shall be bid with Pay Item numbers;

548-\_\_\_ Retaining Wall System (Permanent)

548-\_\_\_ Retaining Wall System (Temporary)



## Exhibit 30-A Permanent Retaining Wall Design Flowchart for Retaining Wall Design\*

Begin Retaining Wall Design to determine:  
 1. **Plan Requirements**  
 2. **Concrete Class, Cover and FDOT Wall Type**

\* Not including sheet pile walls

**1. Plan Requirements**

1. In the General Notes, list the following information for each wall:

- A) anticipated short term, long term, and total settlement
- B) anticipated differential settlement (%)
- C) aesthetic expectations, if any.
- D) for non-MSE Walls (FDOT Wall Type 1): environmental classification (see flow chart below and SDG), concrete class and cover (see SDG), calcium nitrite requirements, and FDOT Wall Type (see 2. below and Table of FDOT Wall Types).

for MSE Walls (FDOT Wall Type 2): concrete class and cover (see flow chart below), calcium nitrite requirements, metal/plastic strap requirements, and FDOT Wall Type (see 2. below and Table of FDOT Wall Types).

for Temporary Walls: FDOT Wall Type 3 (see Table of FDOT Wall Types) and Air Contaminates Classification (Extreme/moderate/Low see flow chart below).

for Two Phase, project specific, or non-proprietary walls, include the complete wall design in the plans.

Include Control Drawings in the plans. When FDOT Wall Type is listed in the plans, the Contractor will select the wall system from the QPL. Shop drawings are required for all QPL walls.

**2. Concrete Class, Concrete Cover, and FDOT Wall Type**

What Wall Settlement Categories are applicable for the project?

**Category 2 Settlement**  
 0" < Total Vertical Settlement ≤ 6"  
 and Differential Settlement ≤ 0.5%  
 (e.g. MSE Walls)

Is the proprietary MSE Wall in the 100 year flood plain with chloride content above 2000 ppm?

Yes → 2. Use 3" cover, Class IV Concrete; Metal soil reinforcement *not* permitted; Calcium Nitrite required if D ≤ 50 feet (splash zone)  
 without Calcium Nitrite  
 List Type 2E in Plans  
 with Calcium Nitrite  
 List Type 2F in Plans

**Category 1 Settlement**  
 0" < Total Vertical Settlement ≤ 2"  
 and Differential Settlement ≤ 0.2%

Total Vertical Settlement > 6"  
 or Differential Settlement > 0.5% → 2. Project Specific Design

What is the distance (D) from the wall to an Environmental Source of Interest?

*Environmental Source of Interest - body of water with high chloride content (greater than 2,000 ppm) or any coal burning industrial facility, pulpwood plant, fertilizer plant or similar industry.*

0 feet < D ≤ 300 feet  
 (extreme air contaminates)

2. Use 3" cover, Class IV Concrete; Metal soil reinforcement permitted; Calcium Nitrite required if D ≤ 50 feet (splash zone)  
 without Calcium Nitrite  
 List Type 2C in Plans  
 with Calcium Nitrite  
 List Type 2D in Plans

300 feet < D ≤ 2,500 feet  
 (moderate air contaminates)

2. Use 2" cover, Class IV Concrete; Metal soil reinforcement permitted  
 List Type 2B in Plans

D > 2,500 feet  
 (low air contaminates)

2. Use 2" cover, Class II Concrete; Metal soil reinforcement permitted  
 List Type 2A in Plans

2. Determine Environmental Classification using Bridge Substructure Rules, then determine Concrete Class and Cover (see SDG)

Extremely Aggressive  
 without Calcium Nitrite  
 List Type 1C in Plans  
 with Calcium Nitrite  
 List Type 1D in Plans

Moderately Aggressive  
 List Type 1B in Plans

Slightly Aggressive  
 List Type 1A in Plans

(CONTINUED ON NEXT PAGE)

**Exhibit 30-A Permanent Retaining Wall Design (Continued)**

Table of FDOT Wall Types																									
Wall Type <sup>1</sup>	Proprietary QPL Item	Settlement Category	Design Settlement Limitations			Durability Category	Durability Factors				Other Allowable Wall Types <sup>7</sup>														
			Total Settlement <sup>2</sup>		Differential Settlement <sup>3</sup>		Typical Wall Construction	Concrete Cover	Concrete Class	Calcium Nitrate	Soil Strap Type	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F				
Type 1	No	1	≤ 2"	and	≤ 0.2%	Cantilever, Gravity, and Counterfort Walls	Project Specific				Project Specific														
Type 1A	Yes						A	2"	II	No	n/a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Type 1B							B	2"	IV	No		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Type 1C							C	3"	IV	No		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Type 1D <sup>4</sup>							D	3"	IV	Yes		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Type 2	No	2	≤ 6"	and	≤ 0.5%	MSE Walls	Project Specific				Project Specific														
Type 2A	Yes						A	2"	II <sup>5</sup>	No	metal	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Type 2B							B	2"	IV <sup>5</sup>	No		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Type 2C							C	3"	IV <sup>5</sup>	No		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Type 2D							D	3"	IV <sup>6</sup>	Yes		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Type 2E							E	3"	IV <sup>5</sup>	No		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Type 2F <sup>4</sup>							F	3"	IV <sup>6</sup>	Yes		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Type 3	Yes	3	n/a		≤ 2.0%	Temporary Walls	n/a				metal/plastic														

1 - Listed in the Plans; Wall Type combines both Settlement Limitations and Durability Factors.  
 2 - Amount of wall settlements that will occur in its design life and includes both short and long term settlements. Short term settlements occur during wall construction and may contain elastic deformation and densification settlement. Long term settlements continue after the completion of the wall and may include consolidation and secondary consolidation/creep settlements.  
 3 - Settlements along the alignment of and perpendicular to the wall face; usually are not uniform. Expansion joints for the cast-in-place walls and slip joints for MSE walls are provided to control wall and wall panel cracks, respectively.  
 4 - Includes all underground walls and walls submerged in water.  
 5 - For concrete requirements, see Specification Section 346 using slightly aggressive environment.  
 6 - For concrete requirements, see Specification Section 346 using extremely aggressive environment.  
 7 - "Other Allowable Wall Types" listed with a "✓", have Settlement Limitations and Durability Factors greater than those required by the "Wall Type" (Column 1).