

Section 5
ABUTMENTS, PIERS AND WALLS

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Section 5
ABUTMENTS, PIERS AND WALLS

5.1 GENERAL

5.1.1 Abutments

An abutment is the portion of the bridge that supports the end of a bridge span, provides lateral support for approach roadway fill and supports the approach roadway and approach slab. Abutments may be described by their location relative to the approach embankments.

A stub (embankment) abutment is located at or near the top of the approach fill. A partial depth abutment is located approximately mid-depth of the front slope of the approach embankment. A full depth (shoulder) abutment is located at the approximate toe of the approach embankments.

Abutment types shall be selected considering structure aesthetics, foundation recommendations, structure location, and the loads it must transmit to the foundation. For structures over waterways, the abutment type and location should also be specified with consideration to hydraulic conditions at the site. Wherever possible, use stub (embankment) abutments for structures over waterways.

The acceptable abutments types include non-proprietary systems such as gravity walls, cantilever walls, counterfort walls and integral abutments. Abutments shall not be placed on fill supported by mechanically stabilized earth walls or prefabricated modular walls. Generally, for abutments and wingwalls founded on rock, where the footings are exposed, the abutment and wingwalls shall be designed without a toe.

5.1.2 Piers

A pier is that portion of the bridge between that provides intermediate support of the superstructure and the foundation. Pier types shall be selected considering structure aesthetics, foundation recommendations, structure location, and the loads it must transmit to the foundation. If possible, on large projects with many piers, the type of pier shall be consistent throughout the entire project for reasons of economy. The acceptable pier types include wall piers, open column bents, multiple column piers, and single column piers. The use of permanent steel pier bents is discouraged due to future maintenance.

5.1.3 Walls

Walls should be used where the construction of a roadway or facility cannot be accomplished with slopes. Walls can be classified as either retaining walls, or

wingwalls. Wingwalls are used to provide lateral support for the bridge approach roadway embankment. For bridges with long wingwalls that are parallel to the roadway, the entire wingwall should be referred to as a retaining wall.

Wingwalls shall preferably be U-type (parallel to the roadway). Flared wingwalls are permitted where conditions warrant such as for hydraulic performance of waterway crossings. The acceptable wingwall types include non-proprietary systems such as gravity walls, cantilever walls and counterfort walls. Proprietary systems, such as mechanically stabilized earth and prefabricated modular walls, shall only be used for retaining walls.

Retaining walls may be non-proprietary systems such as gravity walls, cantilever walls, counterfort walls or tie backwalls, or may be proprietary systems such as mechanically stabilized earth walls or prefabricated modular walls.

The tops of retaining walls shall not be determined by the exact fill slope but shall follow a smooth unbroken line for a more pleasing appearance. This may require the use of vertical curves, in which case elevations shall be given at five foot intervals.

5.1.4 Foundations

The foundation is that part of the structure that serves to transmit the forces acting on the abutments, piers, or walls to the ground. Foundations are classified as either shallow or deep. A shallow foundation derives its support by transferring load directly to soil or rock at a shallow depth. Spread footings are shallow foundations. A deep foundation derives its support by transferring loads to soil or rock at some depth below the structure by end bearing, adhesion or friction or both. Driven piles and drilled shafts are deep foundations.

Foundation type is generally based on the anticipated (structure) loads, underlying soil conditions, scour potential, site constraints along with the ease and cost of construction.

5.2 IDENTIFICATION NUMBERS

All abutments and piers shall be identified by numbers which start with the number "one" and progress consecutively but separately in the direction of stationing of the roadway, such as, Abutment 1, Pier 1, Abutment 2, etc.

All wingwalls shall be identified by a combination of a number and a letter (alphanumerical), such as 3A or 3B. The number used must correspond to the substructure unit to which the wingwall is attached. Looking up station, the letter "A" indicates the wingwall is on the left and the letter "B" indicates the wingwall is on the right.

Retaining walls shall be identified by three numbers that start at 101 and progress consecutively in the direction of stationing of the roadway, such as Retaining Wall 101, Retaining Wall 102.

5.3 EXCAVATION

5.3.1 General

Contract items for structure excavation, unless the work is included under other items, are required for the removal of all material of whatever nature necessary for the construction of foundations for bridges, box culverts, retaining walls and other structures. The contract items specified on the plans depends on the type of material removed, earth or rock, and whether or not separate payment will be made for the work related to cofferdams and dewatering.

On any project where only some of the structures and/or their components require cofferdams and some do not, a combination of structure excavation items shall be shown on the plans. The plans for the structures and components requiring “Cofferdam and Dewatering” shall clearly delineate the limits of the cofferdam.

5.3.2 Construction Requiring Cofferdam and Dewatering

At water crossings, where structures or their components are located partially or wholly in the water and the bottom of the footing is below water level, or where a considerable flow or concentration of water is present that cannot be diverted, partly or wholly, from the site, the plans shall include the following item:

ITEM NAME	PAY UNIT
Cofferdam and Dewatering	L.F.

The hydraulic design of the cofferdam should be done in accordance with Chapter 18 (Temporary Hydraulic Facilities) of the *Drainage Manual*.

The plans shall also include either one or both of the following items, as required for the type of material removed:

ITEM NAME	PAY UNIT
Structure Excavation – Earth (Excluding Cofferdam and Dewatering)	C.Y.
Structure Excavation – Rock (Excluding Cofferdam and Dewatering)	C.Y.

Where underwater (tremie) concrete may be used to seal the bottom of a cofferdam to allow dewatering, the weight of the tremie concrete, adjusted for buoyancy, shall be added to pile and foundation loads for design purposes.

5.3.3 Construction in the Dry

Where structures or their components are to be constructed in the dry or where water may be diverted from an excavation, eliminating the need for a cofferdam, the plans shall also include either one or both of the following items, as required for the type of material removed:

ITEM NAME	PAY UNIT
Structure Excavation – Earth (Complete)	C.Y.
Structure Excavation – Rock (Complete)	C.Y.

The diversion of water or water courses, either partially or wholly, from an excavation or site, must be coordinated with hydraulic studies and DEP, Federal and State permit submittals. At the sites where water is diverted from an excavation, the following item shall be included in the project.

ITEM NAME	PAY UNIT
Handling Water (Site No.)	L.S.

5.4 EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS

Expansion and contraction joints in concrete abutment and wall stems shall be provided in accordance with *AASHTO Specifications*. Construction joints shall be placed as conditions warrant. Expansion or contraction joints should not be provided in footings. Footings for abutments and walls should be continuous including any steps provided.

No reinforcement shall pass through expansion and contraction joints. Reinforcement shall pass through construction joints.

5.5 DAMPPROOFING

The rear face of cast-in-place abutments and wall stems shall be damp-proofed.

5.6 BACKFILL REQUIREMENTS

5.6.1 General

Unless otherwise directed, all abutments, wingwalls and retaining walls shall be backfilled with Pervious Structure Backfill to the limits described below. Pervious Structure Backfill is a clean, granular soil. For design purposes, the effective angle of internal friction shall be taken as equal to 35°.

5.6.2 Backfill Limits

Place a wedge of Pervious Structure Backfill above a slope line starting at the top of the heel and extending upward at slope of 1:1½ (rise to run) to the bottom of the subbase. In cut situations, the following note, with a leader pointing to the slope line, shall be placed on the plans:

Slope line except where undisturbed material obtrudes within this area.

5.7 SUBSURFACE DRAINAGE

5.7.1 General

Subsurface drainage shall be accomplished with the use of weepholes extending through the wall stems or underdrains placed along the wall stems. Subsurface drainage for proprietary retaining walls shall conform to the Department's *Specifications* governing their design and construction.

5.7.2 Weepholes and Bagged Stone

Except for structures placed on embankments, four-inch diameter for dimension weepholes, sloped 1:8 (rise to run), shall be placed approximately twelve inches above the finished grade at the front face of the wall stem. For structures placed on embankments, the weepholes shall be extended through the slope with an outlet. Weepholes shall not drain onto adjacent sidewalks. Weepholes should be spaced at approximately eight to ten feet intervals unless conditions warrant a closer spacing. The spacing and invert elevations of the weepholes shall be shown in an elevation view.

The cost of furnishing and installing weepholes is included in the cost of the concrete. Bagged Stone is paid for as a separate item.

5.7.3 Underdrains

Underdrains shall be a six-inch nominal diameter, perforated and placed at the base of the stem and sloped a minimum of 1%. Underdrains shall be either connected to the roadway drainage or to a free outlet. The location and limits of the underdrain shall be shown in plan view. The invert elevations shall be shown in an elevation view.

Underdrains shall be paid for under the item "6 inch Structure Underdrain." When an underdrain is connected to the roadway drainage, the pipe beyond the face of the wall stem or the end of the wall shall be shown on the plans to be included in the roadway items, and should be coordinated with the roadway designer.

5.7.4 Subsurface Drainage Selection Criteria

5.7.4.1 *Shoulder Abutments*

At abutments in cut situations, either an underdrain or weepholes may be used with the latter being preferred. Weepholes should be used at abutments located on fills. When there is a sidewalk in front of any abutment, an underdrain should be used. Where this type of abutment is used at water crossings, drainage shall be provided by weepholes.

5.7.4.2 *Embankment Abutments*

At abutments in wet cuts, an underdrain should be used. At abutments in dry cuts and fills, extended weepholes should be used. If the total length of pipe for this system exceeds that required for underdrains, the latter is preferred.

5.7.4.3 *U-Type Wingwalls, Flared Wingwalls and Retaining Walls*

For walls with a fully exposed face adjacent to a sidewalk, an underdrain should be used. For walls with a fully exposed face not adjacent to a sidewalk, weepholes should be used. For walls with a partially exposed face, an underdrain should be used.

5.8 APPROACH SLABS

Approach slabs shall be provided on all bridges carrying State highways. Approach slabs shall be strongly considered on all bridges undergoing superstructure replacement and local road bridges.

Approach slabs should extend the full width of the roadway (including shoulders), have a standard length of 16 feet and be 1'-3" thick. Generally, approach slabs should follow the skew of the bridge for skew angles up to 35°. For skew angles greater than 35°, the ends of the approach slabs should be square to the roadway with a minimum length of 15 feet. Acute corners of approach slabs and approach pavement should be squared off for a distance of five feet from the gutter line. Approach slabs shall be anchored to the bridge abutment.

Approach slabs shall be constructed with Class "F" Concrete and have two mats of coated reinforcement. Approach slabs shall be covered with a waterproofing membrane and a bituminous concrete overlay. All the material items used in the construction of the approach slabs, including the overlay, shall be included in the structure items and quantities.

All elevations necessary for construction of the approach slabs shall be shown on the plans. These elevations shall include the elevations at the point of application of grade line, the gutter lines and at shoulder break lines at both ends of the approach slabs.

5.9 SLOPE PROTECTION

Provisions shall be made for protection of earth slopes in front of abutments on bridges over State highways, local roads, railroads and waterways. The slope of the embankment in front of the abutment shall be no steeper than 1:2 (rise to run).

5.9.1 Selection Criteria

The type of slope protection shall generally conform to the following criteria:

- Crushed Stone for Slope Protection shall be used under structures overpassing Interstate highways, railroads and waterways. Protection between the edge of the shoulder and the toe of the slope should be founded on a six-inch granular fill base or geotextile. The limits of this base should be shown on the plans and shall be included in the estimated structure quantities.
- Concrete Block Slope Protection shall be used under structures overpassing State highways and local roads. The block shall be anchored or mortared into place to prevent vandalism. The use of granite block is not permitted due to its higher cost. Cast-in-place concrete is not permitted due to cracking and settlement of existing installations.
- Abutment slope protection for bridges over waterways should be designed in accordance with the procedures outlined in HEC-18 or successor documents as well as documents referenced therein.

5.9.2 Limits of Slope Protection

The limits of slope protection shall cover the complete area, exclusive of sidewalks, from the edge of the shoulder to the face of the abutment stem and transversely within lines parallel to and two feet outside of the bridge rails.

5.9.3 Inspection Shelf

Provisions for inspection access (for bridge inspectors) shall be provided on all slopes. On stems with exposed heights less than or equal to five feet, access shall be provided by a shelf at the top of the slopes. On stems with exposed heights greater than five feet, access may be by a shelf at the top of the slopes or ladder steps on the slope itself. The plans shall include details of the intersection of the shelf and the slope along the wingwalls.

5.10 SURFACE TREATMENTS

5.10.1 General

In general, abutments, piers and walls shall be faced with standard formed concrete. Surface treatments other than standard formed concrete should only be considered in the following situations:

- When the structure has been determined by the Department to be architecturally or historically significant.
- If there is a desire expressed for special surface treatments during the public involvement process of the project. The basis for surface treatments should involve the character of the area in which the wall is to be built. The use of special surface treatments should be coordinated with the town or city administration.
- Where the structure is to be built on a designated State scenic highway.
- The structure is part of the Merritt Parkway. For these structures, every attempt should be made to replicate the appearance and structure type that was originally built.
- The treatment of the structure is part of a right-of-way settlement with a property owner. For instance, if a property has an existing stone wall that is to be removed and relocated, the owner may request that the replacement wall also have a stone surface.

If special surface treatments are desired for a particular structure, every attempt should be made to achieve architectural aesthetics by means of shape and form, not through surface treatments alone. Surface treatments should generally be used in conjunction with the shape of the structure.

5.10.2 Form Liners

When the use of surface treatments has been determined to be appropriate, the preferred method is the use of concrete form liners. Form liners offer a lower cost alternative to stone veneer. There is a wide variety of form liners available for different architectural treatments. Linear corrugated form liners should be avoided since it is difficult to hide joint lines and form tie holes. Form liners that replicate stone are preferred since the random nature of the surface makes it easy to hide form tie holes.

5.10.3 Simulated Stone Masonry

In more sensitive areas, where the look of real stone is required, the use of simulated stone masonry may be considered. Simulated stone masonry utilizes a flexible form

liner system and color stains to provide the aesthetic appeal of natural stone with the durability of reinforced concrete.

5.10.4 Stone Veneer

The use of stone veneer on concrete should only be considered in very sensitive areas where the increased cost can be justified. Stone veneer shall only be used with approval from the Department.

5.11 REQUIREMENTS FOR ABUTMENTS

5.11.1 General

The abutments shall be designed, unless otherwise noted, in accordance with the *AASHTO Specifications*.

Generally, abutments shall be constructed of reinforced concrete. Cast-in-place footings and stems shall be constructed with Class "A" Concrete.

Generally, reinforcement in footings and stems of abutment and wingwalls shall be uncoated. Coated reinforcement shall be used in abutments and wingwalls when they are subject to corrosive materials such as salt water, chemicals, etc. Provide a minimum of three-inch concrete cover over the reinforcement in the front face abutments. The concrete cover over the reinforcement in footings shall also be three inches.

5.11.2 Gravity Cantilever and Counterfort Abutments

5.11.2.1 *Steel Girder and Concrete Bulb Tee and Box Girder Bridges*

Gravity, cantilever, and counterfort walls, with bridge seats, may be used for abutments.

Bridge seats shall be sloped with a minimum two-inch draw from the front face of the backwall and closed at the ends. When determining bridge seat widths, consideration shall be given to superstructure jacking requirements as given in subarticle 7.2.13 and the clear distance requirements between the end bearing diaphragms and the front face of the backwall as given in subarticle 7.3.3.7. On bridges constructed with box girders, the clear distance from the end of the box girder to the face of the backwall should be no less than two feet.

At the elevation of the bridge seat, the minimum dimension from the front face of the abutment stem to the centerline of the bearings shall be 1'-3". The minimum backwall thickness shall be 1'-3". Stem thicknesses may be less than the combined dimensions of the bridge seat and backwall.

5.11.2.2 *Butted Deck Unit and Box Beam Bridges*

Gravity, cantilever and counterfort walls, with bridge seats, may be used for abutments.

Bridge seats shall be sloped to match the grade of beams.

At the elevation of the bridge seat, the minimum dimension from the front face of the abutment stem to the centerline of the bearings shall be nine inches. The minimum backwall thickness shall be 1'-3". Stem thickness may be less than the combined dimensions of the bridge seat and backwall.

5.11.3 *Integral Abutments*

Integral abutments are defined as abutments that are cast integrally with the superstructure. Integral abutments should be considered on all bridges, and especially where pile supported foundations are required, since the use of integral abutments will greatly reduce the number of piles and simplify the abutment details.

All integral abutment bridges shall be designed with full width approach slabs in order to minimize surcharge loads and hydrostatic pressures. Integral abutments shall be designed with U-Type wingwalls.

5.11.3.1 *Fully Integral Abutments*

Fully integral abutments are defined as abutments that are integral from the superstructure through to the piles. In order to control the effects of the soil mass on the abutment, the maximum height of the cast-in-place abutment shall be eight feet.

The piles shall be placed in a single line and typically are oriented such that the weak axis of the pile is parallel to the abutment face. For design purposes, the connection of the superstructure to the substructure shall be modeled as a pinned connection. The piles shall be designed for vertical forces only. The effects of thermal expansion, end rotation of the superstructure, and soil forces should be neglected.

5.11.3.2 *Semi-Integral Abutments*

Semi-integral abutments are defined as abutments that are integral from the superstructure through a portion of the abutment stem. Typically, a joint will be detailed in the abutment stem. In order to control the effects of the soil mass on the abutment, the maximum height of the integral portion of the cast-in-place abutment shall be eight feet.

For design purposes, the connection of the superstructure to the substructure shall be modeled as a pinned connection. The lower portion of a semi-integral abutment shall be designed as a standard cantilever abutment with all vertical forces from the superstructure transmitted to lower portion of the abutment.

5.12 REQUIREMENTS FOR PIERS

5.12.1 General

The piers shall be designed, unless otherwise noted, in accordance with the AASHTO *Specifications*. Generally, piers shall be constructed of reinforced concrete. While the design of steel pier caps is allowed, they are however discouraged. For additional information, see Section 7. Piers may be made integral with the superstructure.

Footings shall be constructed with Class "A" Concrete. Generally, concrete pier stems, columns, and pier caps shall be constructed with Class "F" Concrete. Post-tensioned concrete pier caps may require concrete with greater compressive strengths.

All reinforcement in piers shall be uncoated. The concrete cover over the reinforcement in pier footings, stems, columns, and pier caps shall be three inches.

Circular concrete columns are preferred over rectangular concrete columns. With circular columns, spiral reinforcement is preferred over ties.

Cantilever concrete pier caps shall be post tensioned in order to eliminate cracking. The design shall be based on zero tension in the top of the cap after all losses have occurred under all loads.

The top surfaces of concrete piers and concrete pier caps shall have a transverse slope of 1:10 (rise to run). The slope shall be in both directions from the centerline to the face of the pier with a minimum draw of two inches.

Drilling holes for anchor bolts will not be permitted in concrete pier caps. Anchor bolts installed before the concrete is placed shall be set and held accurately by a template. Anchor bolts to be set after the concrete is poured shall be set in forms that shall be placed before the concrete is poured. The designer shall indicate on the plans which method of setting anchor bolts is to be used.

For structures over waterways, the following criteria applies:

- Pier foundations on floodplains should be designed to the same elevation as pier foundations in the stream channel if there is likelihood that the stream channel will shift its location over the life of the bridge.

- Align piers with the direction of flood flows. Assess the hydraulic advantages of round piers, particularly where there are complex flow patterns during flood events.
- Streamline piers to decrease scour and minimize the potential for the buildup of ice and debris. Use ice and debris deflectors where appropriate.

5.12.2 Wall Piers

A wall pier consists of a solid wall that extends up from its foundation. Generally, wall piers or wall piers combined with open bents should be considered at water crossings. Wall piers offer minimal resistance to water and ice flows.

5.12.3 Open Column Bents

An open column bent consists of a pier cap beam and supporting columns in a frame-type structure. Open column bents should be considered for wide overpasses at low skews.

Open column bents founded on rock shall generally be designed with isolated footings while open column bents founded on soil shall generally be designed with combined footings. When these piers are founded on piles, they may be designed with either isolated or combined footings.

5.12.4 Multiple Column Piers

A multiple column pier consists of an individual column supporting each beam or girder. Multiple column piers should be considered for wide overpasses at low skews.

5.12.5 Single Column Piers

Single column piers are simple, easy to construct, require minimum space, and provide open appearance to traffic. Single column piers may have a hammer head pier cap. Hammer head piers should be considered for overpasses at high skews with tight alignment constraints. This type of pier provides open appearance when supporting structures with long spans.

5.12.6 Protection from Adjacent Traffic

To limit damage to piers by vehicular traffic, crash walls shall be provided. The minimum height of the wall shall be 42 inches, and shall be placed a minimum of six inches from the face of the pier.

To limit damage to piers by railroad equipment, crash walls shall be provided in accordance with AREMA Specifications. Extensions to crash walls may be required to satisfy site conditions. The top surface of the crash wall shall have a transverse slope of 12:1.

5.13 REQUIREMENTS FOR WALLS

5.13.1 General

The following is a listing of appropriate retaining wall types that may be considered:

1. Non-Proprietary: Cast-In-Place Reinforced Concrete.
2. Proprietary: Prefabricated Modular Wall Systems.
Mechanically Stabilized Earth Walls (precast concrete).
Mechanically Stabilized Earth Embankment Walls (dry-cast block).

A design is required for the non-proprietary walls only. The Contractor shall be responsible for the structural/internal design of the proprietary walls. The design drawings shall be signed, sealed and dated by a qualified Professional Engineer, licensed to practice in the State of Connecticut. For projects where proprietary retaining walls are included, the walls will be bid as a lump sum for each site. The designer shall clearly define the horizontal, vertical, and transverse pay limits on the plans.

The Department maintains a list of approved proprietary retaining walls for each category listed above. No other proprietary retaining walls will be allowed.

5.13.2 Wall Selection Criteria

The designer shall select the appropriate retaining walls for each site. The designer may need to contact wall manufacturers to insure that each wall will be suitable at each site, and fit within the available right-of-way. The following general criteria should be followed for the selection of appropriate retaining walls:

5.13.2.1 Walls Less Than Eight Feet (measured from front grade to back grade)

5.13.2.1.1 Embankment Walls

Embankment walls are defined as mechanically stabilized earth structures faced with dry cast concrete block that are less than eight feet high and support an embankment. Embankment walls are typically used to support earth only, not roadways or where there is a potential for future underground utilities or drainage structures. The mechanical strength of the wall comes from soil reinforcements comprised of either geogrids or welded wire mesh.

Embankment walls are proprietary wall systems, and there are several approved manufacturers of these types of walls. It is not necessary to design a cast-in-place retaining wall as an alternate; however, the designer shall lay out the embankment wall on the plans with at least the following information:

- Retaining wall plan view with all required dimensions, contours, property lines, utilities, etc.
- Retaining wall elevation view showing top and bottom elevations, approximate step locations, existing and finished grade, etc. Where required, the designer shall also show the location of railings or fences required to be attached to the top of the wall.
- Typical sections (schematic) of the wall showing pay limits and minimum drainage requirements.
- Borings and soils information including the maximum allowable bearing pressure.
- Temporary Sheet piling required for excavation.

5.13.2.1.2 Cast-in-Place Walls

For locations where embankment walls are not appropriate (in accordance with the criteria listed above), a cast-in-place wall should be designed and detailed.

At the discretion of the Department, proprietary walls may also be allowed if the wall is very long resulting in a large overall area. The designer shall provide the same information for proprietary walls as required in Article 5.13.2.2.1.

If the appearance of stone is desired, architectural form liners should be used. These liners are significantly less costly than stone veneer. If there are multiple walls on a project, the surface treatment shall be similar for each wall.

5.13.2.2 Walls Over Eight Feet (measured from front slope to back slope)

5.13.2.2.1 Walls With Less Than 5000 ft² of Vertical Face Area (Measured to Bottom of Footing)

For this situation, a cast-in-place wall should be designed to be bid against the proprietary walls. The Contractor may be able to build the cast-in-place wall with his own forces at a lower cost. For these situations, the designer shall completely design and detail the cast-in-place wall. For the proprietary retaining wall, schematic typical cross sections combined with the cast-in-place details should be enough for the proprietary wall manufacturers to design their walls.

The designer shall provide a list of the specific proprietary walls allowed for each site. For instance, the designer may limit the selection based on the available right of way at a site.

For mechanically stabilized earth walls with metallic soil reinforcements that are to be built in areas of potential stray currents within 200 feet of the structure (for example: an electrified railroad), a corrosion expert shall evaluate the potential need for corrosion control requirements.

If the wall is required to be designed for seismic loads, it shall be stated in the notes for the wall.

5.13.2.2.2 Walls With Over 5000 ft² of Vertical Face Area

For this situation, proprietary retaining walls will most likely be more economical; therefore, a cast-in-place wall design should generally not be done except where site conditions or soil constraints may require a cast-in-place wall. The designer shall determine which proprietary retaining walls are appropriate for each site. The designer shall also lay out the proprietary retaining walls on the plans with at least the following information:

- A list of the specific walls allowed for each site. For instance, the designer may limit the selections based on the available right of way at a site.
- Retaining wall plan view with all required dimensions, offsets, contours, property lines, utilities, etc.
- Retaining wall elevation view showing top and bottom elevations, approximate footing step locations, existing and finished grade, etc. Where required, the designer shall also show the location of railings or fences, light standard and/or sign support anchorage locations, rigid metal conduit and junction boxes.
- Typical Sections (schematic) of the wall showing pay limits and minimum drainage requirements. Specific details are not required for each wall manufacturer, only for each wall type.
- All soils information normally used for the design of a cast-in-place wall shall be shown on the plans including but not limited to borings and allowable soil bearing pressures.
- Temporary Sheet piling required for excavation.
- If the wall is required to be designed for seismic loads, it shall be stated in the notes for the wall.
- For mechanically stabilized earth walls with metallic soil reinforcements that are to be built in areas of potential stray currents within 200 feet of the structure (for example: an electrified railroad), a corrosion expert shall evaluate the potential need for corrosion control requirements.

5.13.2.3 *Architectural Treatments*

If the appearance of stone is desired, architectural form liners should be used. These liners are significantly less costly than stone veneer. Several of the proprietary retaining walls can be built with form liners resembling stone. The designer should contact the approved wall manufacturers for specifics about available form liners. Every effort should be made to keep the surface treatment similar for all the wall types specified.

5.13.2.4 *Large Anticipated Settlements and Liquefaction*

If large settlements or liquefaction are anticipated that require a wall supported on piles, in general, proprietary retaining walls should not be used. Even though these walls can accommodate some settlement, the opening and closing of the joints would produce an undesirable appearance. For these situations, a cast-in-place wall should be designed supported on piles, or the proprietary retaining walls shall be detailed with pile supported full width footings.

5.13.2.5 *Walls Supporting Roadways*

If the wall supports a roadway where there is a possibility of future underground utilities and drainage structures, mechanically stabilized earth walls should not be used. This would not be the case for walls supporting limited access highways. If the utilities are extensive or deep, it may not be possible to use the modular wall options either.

5.13.2.6 *Multiple Walls in Same Project*

If there are several retaining walls within the same project, the designer may wish to require that all walls selected by the Contractor for the project be manufactured by the same wall supplier. This is especially true for walls that are close together.

5.13.2.7 *Pre-Construction Procedures*

The designer should contact the wall companies for tall walls or walls with unusual geometry to be sure that the proprietary walls will function at each site. This should be done during the preliminary design phase of the project.

Prior to construction advertising, the designer should inform in writing each proprietary wall company that they are listed as acceptable alternates on the contract plans. This will allow them to obtain plans and specifications in order to accomplish preliminary design during advertising for the project. Part of this submission should include the anticipated advertising date.

5.13.3 Requirements for Cast-in-place Non-Proprietary Walls

5.13.3.1 *Flared Type Wingwalls and Retaining Walls*

The stems of flared type wingwalls shall be 1'-4" wide at the top, with the rear face battered. The minimum batter shall be 10:1.

5.13.3.2 *U-Type Wingwalls with Sidewalks*

The top of the wingwall section shall conform to the parapet width for the full length. If a batter is required, the rear face shall be vertical to approximately twelve inches below the sidewalk.

5.13.3.3 *U-Type Wingwalls with Sloped Curb*

The top of the wingwall section shall conform to the parapet width for the full length. If a batter is required, the rear face shall be vertical to approximately twelve inches below the bottom of subbase.

5.14 REQUIREMENTS FOR FOUNDATIONS

5.14.1 Structures over Waterways

Substructures for bridges over waterways shall be designed to safely support the structure subjected to the design scour. This policy is based upon the design guidelines contained within the FHWA document entitled "Evaluating Scour at Bridges" (HEC-18), wherein it states that "Bridges should be designed to withstand the effects of scour from a superflood with little risk of failing."

With regard to abutment or pier foundations, two basic approaches to achieving this goal are available to the designer, listed as follows in order of preference:

- a) Design the foundation to resist the effects of scour from a superflood.

Foundations subjected to scour shall be designed with footings supported on piles, footings founded on rock or deep footings (located below the maximum estimated scour). Structural tremies (concrete poured under water which directly supports the foundation loads) will be allowed in very limited situations, only where no other solution is feasible, and only with the approval of the Department. Preference for foundations adjacent to or within waterways will be for pile supported footings or direct foundations on rock. For pile foundations, the top of footing shall be set below the sum of the long-term degradation and contraction scour.

- b) Protect the substructure units with riprap or similar armoring layers.

In general, the use of riprap to provide scour protection for new bridges is discouraged and should be used only where it has been demonstrated that alternate, preferred means of designing bridges to be safe from scour related failures are not feasible. On bridge rehabilitation projects where the substructure is being repaired and incorporated in the reconstruction of the bridge, riprap scour countermeasures may be an effective solution for protecting the bridge from scour.

The designer should explore and incorporate into the design all reasonable methods of minimizing local scour, such as the use of embankment or “stub” abutments placed at the top of a protected slope. These types of abutments are much less susceptible to scour than full height abutments. The use of stub abutments does not relieve the requirement for founding on piles or directly on rock. Piers that may experience local scour should be flow aligned and should have streamlined end sections.

5.14.2 Spread Footings on Soil

The top of all footings in soil should be a minimum of twelve inches below the finished grade. The bottom of all footings in soil shall not be less than four feet below, measured normal to the finished grade.

Generally, the use of footing keys to develop passive pressure against sliding is not allowed. The use of passive earth pressure along the sides of foundations to prevent sliding is also not allowed. Resistance from sliding shall be attained through friction between the foundation and the supporting material. The coefficient of friction between the bottom of the footing and the supporting soil shall be a maximum of 0.60.

The plans shall show the following:

- The maximum design foundation pressure under Group I loads for each foundation section. After reducing the other group loads by the percentages permitted by AASHTO, if some other group loading controls the design, also show the maximum design foundation pressure for that group. All design foundation pressures should be identified by group number.

Example: Maximum Design Foundation Pressure = 3.2 TSF (Group II)
2.8 TSF (Group I)

- If applicable, also show the maximum design foundation pressure under seismic loads for each foundation section. The design foundation pressures should be identified as “Group VII.”

Example: Maximum Design Foundation Pressure = 3.6 TSF (Group VII)

5.14.3 Foundations on Rock

Generally, for cast-in-place construction, gravity-type or semi-gravity L-type sections shall be used for abutments, wingwalls and retaining walls founded on rock. There is no minimum embedment for footings placed on competent rock. Generally, structural underwater concrete is not permitted.

5.14.4 Driven Piles

Piles may be either end bearing or friction or a combination of the two. Piles end bearing on bedrock or dense hardpan typically are steel H-piles. Piles driven through a high compacted fill or into native soil containing numerous boulders and cobbles shall be steel H-piles. Generally, H-piles shall conform to the requirements of ASTM A709 Grade 36. Friction piles shall be used for most other cases. Generally, friction piles are precast concrete, cast-in-place concrete or prestressed concrete. Timber piles are not permitted.

Piles may be installed vertical or battered. The path of battered piles should be checked to insure the piles remain within the right of way and do not interfere with piles from adjacent and existing substructure units, nor conflict with temporary sheeting or cofferdams.

Pile foundations supporting abutments shall have a minimum of two rows of piles, unless the piles are incorporated into a fully integral abutment. Piles shall be anchored to and embedded in the footings a minimum of twelve inches.

Maximum pile spacings and maximum allowable design loads should be utilized to minimize the number of piles. The lateral resistance of a pile pattern is the combination of the lateral component of the force acting on the battered piles and the lateral resistance of each pile, vertical and battered, in the pattern. Rear piles shall be investigated for vertical load for the case of 75% of the lateral earth pressure acting on the substructure stem.

The top of all footings should be a minimum of twelve inches below the finished grade. The bottom of all pile caps shall not be less than four feet below, measured normal to the finished grade.

For H-piles, pile point reinforcement and splices shall be prefabricated. The plans shall specify that the Contractor is required to submit pile point reinforcement and splice details to the Engineer for review and approval.

This following note shall be included on the contract drawings:

Prior to driving the piles, the Contractor shall submit to the Engineer for review and approval his method and sequence of pile driving.
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The pile plan(s) included in the contract drawings shall show or note the following:

- A legend denoting vertical, battered and test piles.
- The number, location and length of test piles.
- The location of load test pile(s), if applicable.
- The number, location and estimated length for vertical and battered production piles.
- Material designation of piles, including pile point reinforcement and splices.
- The maximum design axial pile loads under Group I loads for each foundation section. After reducing the other group loads by the percentages permitted by AASHTO, if some other group loading controls the design, also show the maximum design pile load for that group. All design pile loads should be identified by group number.

Example: Maximum Design Pile Load = 57 tons (Group II)
55 tons (Group I)

For structures designed for seismic loading conditions, also show the maximum design axial pile loads under seismic loads for each foundation section. The design pile loads should be identified as "Group VII."

Example: Maximum Design Pile Load = 67 tons (Group VII)

5.14.5 Drilled Shafts

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5.15 SHEET PILING AND COFFERDAMS

5.15.1 Sheet Piling

The location and limits, both horizontal and vertical, of the sheet piling contract items shall be shown at each location.

Permanent Sheet Piling is defined as sheet piling that is required for permanent structural support to protect the structure.

Temporary Sheet Piling is defined as sheet piling that is required for the temporary support during construction. Sheet Piling shall be designated on the plans to be left in place only if its removal may be detrimental to the structure. The item "Sheet Piling Material Left in Place" shall be used only for temporary sheet piling designated by the

designer to be left in place. Temporary Sheet Piling requested by the Contractor to be left in place for his own convenience is not eligible for any additional payment, and the item "Sheet Piling Material Left in Place" shall not be used.

Sheet Piling adjacent to railroad tracks for either permanent or temporary installations shall be designed for each specific location and shown on the plans. The design shall be submitted to the railroad for review. Pay items that apply to railroads must have the word "Railroad" in parentheses (Railroad) following each title.

The following table illustrates the conditions governing the use of sheet piling:

CONTRACT ITEMS	"Permanent Steel Sheet Piling"	"Temporary Sheet Piling" & "Sheet Piling Material Left in Place"	"Temporary Sheet Piling"
INFORMATION REQUIRED ON PLANS	Show horizontal and vertical pay limits of Permanent Steel Sheet Piling. Designer responsible for design.	Show limits of temporary sheet piling. Contractor responsible for design.	Show limits of temporary sheet piling. Contractor responsible for design.
PLAN NOTES	Permanent Steel Sheet Piling to be left in place	Temporary Sheet Piling to be left in place	Temporary Sheet Piling

5.15.2 Cofferdams

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