Chapter 630 Wingwalls

630.01 General

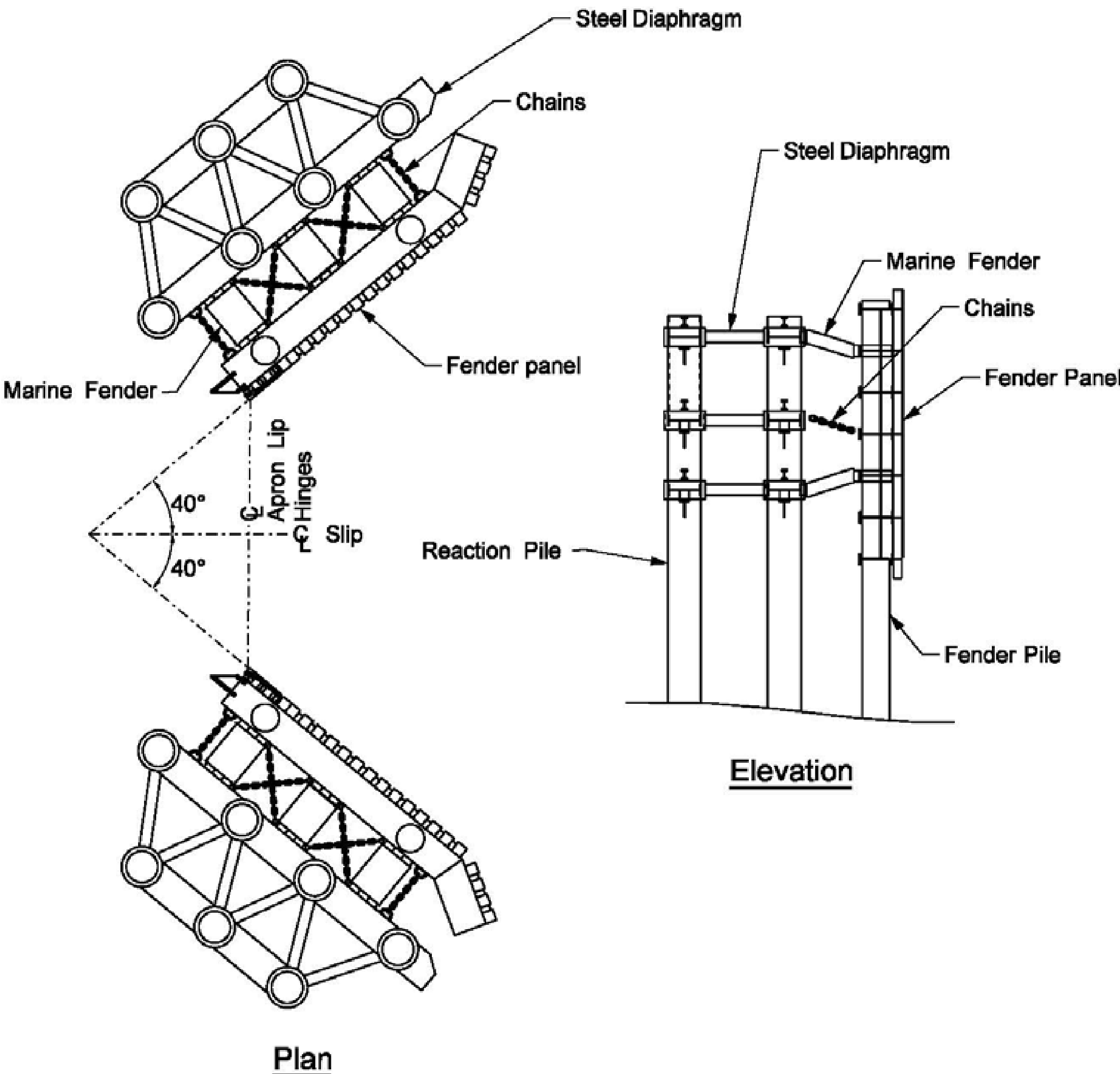
This chapter provides guidance on the design of wingwalls. Wingwalls serve as the primary structure used to stop and hold the vessel in place for loading, unloading and overnight tie-up. Wingwalls serve both operating slips and tie-up slips.

Typical wingwalls are illustrated in Exhibit 630-1. The principal components of wingwalls are illustrated in Exhibit 630-2.

Typical Wingwalls
Exhibit 630-1

For additional information, see the following chapters:

Chapter	Subject
320	Environmental Considerations
330	Marine



Typical Wingwall Layout and Components
Exhibit 630-2

630.02 References

Unless otherwise noted, any code, standard, or other publication referenced herein refers to the latest edition of said document.

(1) Federal/State Laws and Codes

Structural Welding Code – Steel (AWS D1.1: 2010)

WAC 296-24 *General safety and health standards*

WAC 296-56 *Safety standards – longshore, stevedore and waterfront related operations*

WAC 296-876 *Ladders, portable and fixed*

(2) Design Guidance

ASD/LRFD Manual for Engineered Wood Construction (ANSI/AF&PA NDS-2005), American Forest and Paper Association

Bridge Design Manual LRFD M 23-50

Design: Moorings, Unified Facilities Criteria (UFC) 4-159-03, Department of Defense, 2005

Design: Piers and Wharves, UFC 4-152-01, Department of Defense, 2005

General Special Provisions

Geotechnical Design Manual M 46-03

Guidelines for the Design of Fender Systems: 2002, The World Association for Waterborne Transport Infrastructure (PIANC), 2002

Minimum Design Loads for Buildings and Other Structures (ASCE/SEI 7-10), American Society of Civil Engineers

Region General Special Provisions, WSF

SSPC Painting Manual – Volume 2 Systems and Specifications (2011 Edition)

Specification for Structural Steel Buildings (ANSI/AISC 360-05), American Institute of Steel Construction

Standard Specifications for Road, Bridge, and Municipal Construction M 41-10

630.03 Design Considerations

(1) Location

To ensure proper fit by all of the vessels in the fleet, locate the wingwalls at a standard position in relation to the apron lip hinge centerline, at a standard distance from the slip centerline, and at a standard angle (40 degrees) from the slip centerline, unless noted otherwise in the project calculations. Align the throat of each wingwall with the hinge line of the apron lips (roughly the point of contact between the steel apron and the vessel deck) and locate it 12 feet from the slip centerline. The throat is defined as the point formed by the intersection of the face of the UHMW polyethylene rubbing surface and the shoreward end of the steel fender panel wale.

Locate wingwalls for tie-up slips to accommodate placement of the gangplank on the vessel car deck.

(2) Environmental

Refer to Chapter 320 for general environmental requirements and design guidance. Refer to the project NEPA/SEPA documentation for project-specific environmental impacts and mitigation.

(3) Marine

Refer to Chapter 330 for general marine design criteria pertaining to wingwalls. Below are links to relevant sections by topic.

- Operations and Maintenance: 330.04(4)
- Proprietary Items: 330.04(6)
- Long Lead Time Items: 330.04(7)
- Design Life: 330.04(8)
- Corrosion Mitigation: 330.04(9)
- Scour and Mudline Elevations: 330.04(10)
- Material Specifications: 330.04(12)
- Tidal Information: 330.06
- Slips: 330.07
- Berthing and Mooring Criteria: 330.08

(4) Geotechnical Requirements

Design piles in accordance with the Geotechnical Recommendations provided by the WSDOT Geotechnical Branch. Do not include seismic effects including liquefaction in the design. The Geotechnical Recommendations will typically include:

- Axial capacity of piles
- Input data for L-Pile lateral analysis
- Group reduction factors due to pile spacing
- Constructability recommendations including type and capacity of pile driving equipment and use of cutting shoes.

630.04 Design Criteria

(1) General

Wingwalls are flexible pile-supported structures designed to absorb a vessel's kinetic energy through rotation and bending of the fender and reaction piles, compression of the marine fenders, and movement of the piles through the soil. Size wingwalls in accordance with the design energy which is a function of the design vessel's mass and velocity, and other variables and constants.

(2) Design Vessel

Refer to Chapter 330 for design vessel information and Appendix O for vessel particulars. Consider WSF's future plans for vessel assignment to the subject terminal and slip. The design vessel is determined in consultation with WSF Operations staff.

(3) Design Life

Design lives for the following components of the wingwalls are based on deterioration due to corrosion and/or fatigue in accordance with the LCCM.

- Piles, fender frames, and reaction frames: 50 years
- Marine fenders: 30 years
- Timber rubfaces: 20 years
- UHMW polyethylene rub panels: 20 years
- Chain and hardware: 20 years

(4) Design Loads

Design wingwalls for dead loads, live loads, berthing forces, and overnight mooring conditions. Wind, wave, current, and tide effects are considered insignificant and are not included in the analysis. Seismic forces also are not included in the analysis.

Design the wingwalls with load definitions, factors, and combinations in accordance with the provisions of Section 2.4 of *Minimum Design Loads for Buildings and Other Structures (ASCE/SEI 7-10)*, except as modified below.

(a) Load Definitions

D = dead load of structural components and nonstructural attachments

L = live loads

CV = vessel collision force

(b) Dead Loads, D

Dead loads associated with the structure are permanent loads that do not change during the service life of the wingwalls. Dead loads include:

- Weight of the steel piling and structural steel
- Weight of the rub timbers
- Weight of the fender system

Use the following material unit weights for calculation of loads:

Material	Unit weight (lb/ft3)
Steel (all types)	490
ACZA-treated Timber	45
Rubber	80
UHMW	60

Material Unit Weights (in air) for Structural Loading
Exhibit 630-3

(c) Live Load, L

Live loads associated with the normal operation of the wingwalls are loads that could change during the mode of operation considered and are controllable through operating procedures. Live loads consist of the Type I berthing event and maintenance crew loading of ladders and platforms. Personnel are never on the wingwalls during berthing events.

(d) Vessel Collision Load, CV

Vessel collision load consists of the Type III berthing event.

Design Load	Combination
Type I Impact (Piling and all other Steel, Foundations, Deflection Analysis)	S = D + L
Type III Impact (Pushover Analysis)	S = D + CV

Load Combinations
Exhibit 630-4

(5) Design Velocities and Energies

The design energy for wingwalls is calculated using a standard Type I Impact berthing velocity (see Exhibit 630-5). The design velocity has been adopted based on experience from previous WSF wingwall projects. The vessel impact velocity for the tie-up slip is typically two-thirds of the velocity of the operating slip due to the fact that a vessel uses the tie-up slip only at the end of the day when it is not maintaining a service schedule. At certain terminals unusual conditions may require a reduced approach velocity. For example, at Friday Harbor, the presence of marinas adjacent to the slip dictates an approach velocity of 1.0 knot for both the operating slip and the tie-up slip.

Type III berthing velocity is used as the extreme event load case for operating slip wingwalls and assumes a loss of propulsion or other atypical berthing event. The Type III velocity is based on the typical approach velocity as measured at the outer dolphin from global positioning data furnished by WSF Operations staff. Data are in the form of approach velocity-versus-distance from the apron. Drag acts to reduce the impact velocity during any coasting that occurs after loss of propulsion. Use Type III velocity data provided by WSF Operations staff to complete the table shown in Exhibit 630-6.

Calculate design berthing energies in accordance with the provisions of Section 5-2 of the *UFC: Design: Piers and Wharves (UFC 4-152-01)*, unless noted otherwise in the project criteria.

Complete the tables shown in Exhibit 630-5 and Exhibit 630-6.

Wingwall	Vessel Impact Velocity (knots)	Vessel Impact Velocity (feet per second)	Design Energy (kip-feet)
Operating Slip	1.5	2.53	calculated
Tie-up Slip	1.0	1.69	calculated

Type I Impact Berthing Velocities and Energies
Exhibit 630-5

Wingwall	Vessel Impact Velocity (knots)	Vessel Impact Velocity (feet per second)	Design Energy (kip-feet)
Operating Slip	calculated	calculated	calculated

Type III Impact Berthing Velocity and Energy
Exhibit 630-6

It is WSF practice to use 50 percent of the total design berthing energy for the design of an individual wingwall. The vessel is assumed either to contact both wingwalls simultaneously or to contact a single wingwall while continuing to slide or rotate as forward movement continues. The initial impact on one wall will eventually load both walls relatively equally as the vessel slides along the wall toward the centerline of the slip.

(6) Pile Allowable Stress

Design steel piles for an allowable stress in flexure of 0.90 times the yield stress under normal operating conditions (Type I Impact).

630.05 Wingwall Alternatives

The standard wingwall design utilizes pile fixity in the soil and one or more non-rigid diaphragms at the top of the reaction piles to achieve the required structural stability and flexibility (see Exhibit 630-2). At the majority of terminals there exists adequate soil depth to allow piles to be driven, either by vibratory or impact methods, to the embedment required for fixity. The loose connection between the steel diaphragms and the pile tops allows the piles to act as cantilevers, thereby contributing to the energy absorption capacity of the wingwall as a whole.

At those terminals where inadequate soil or especially hard soil exists (for example at Shaw and Orcas), alternative designs have been developed in which fixity is achieved at the pile top through a rigid connection to the frame and an unfixed (or pinned) condition is achieved at the pile tip- bedrock interface. Tensioned and non-tensioned ground anchors typically are used to ensure adequate uplift and shear capacity at this interface (see Exhibit 630-7).

In both cases, energy absorption is achieved through a combination of pile bending, reaction frame displacement and rotation, and marine fender compression.

Wingwall Ground Anchors
Exhibit 630-7

630.06 Miscellaneous Design

(1) Vessel Tie-up and Navigational Aids

Consult with WSF Operations staff to determine the location of tie-up mooring lines. The right wingwall is typically outfitted with a fog light that provides an aid to navigation at night (see Exhibit 630-8).

Wingwall Fog Light
Exhibit 630-8

(2) Ladders

Furnish each operating slip wingwall with a rescue ladder sized to meet all applicable WAC and OSHA requirements and locate adjacent to the vehicle transfer span apron (see Exhibit 630-1). Furnish each tie-up slip wingwall with a rescue ladder sized to meet all applicable WAC and OSHA requirements and located adjacent to the gangplank. In addition, each wingwall that is outfitted with night tie-up lines requires a ladder to access the top mooring line bracket.