AASHTO 2002

TABLE 5.5.2B Ultimate Friction Factors and Friction Angles for Dissimilar Materials, After U.S. Department of the Navy (1982)

Interface Materials	Friction Factor $f = \tan \delta$ (dim)	Friction Angle, δ (degrees)
Mass concrete or masonry on the following foundation materials:		
—Clean sound rock	0.70	35
—Clean gravel, gravel-sand mixtures, coarse sand	0.55 to 0.60	29 to 31
—Clean fine to medium sand, silty medium to coarse sand, silty or clayey gravel	0.45 to 0.55	24 to 29
—Clean fine sand, silty or clayey fine to medium sand	0.35 to 0.45	19 to 24
—Fine sandy silt, nonplastic silt	0.30 to 0.35	17 to 19
—Very stiff and hard residual or preconsolidated clay	0.40 to 0.50	22 to 26
—Medium stiff and stiff clay and silty clay	0.30 to 0.35	17 to 19
Steel sheet piles against the following soils:		
—Clean gravel, gravel-sand mixtures, well-graded rock fill with spalls	0.40	22
—Clean sand, silty sand-gravel mixtures, single size hard rock fill	0.30	17
—Silty sand, gravel or sand mixed with silt or clay	0.25	14
—Fine sandy silt, nonplastic silt	0.20	11
Formed concrete or concrete sheet piling against the following soils:		
—Clean gravel, gravel-sand mixtures, well-graded rock fill with spalls	0.40 to 0.50	22 to 26
—Clean sand, silty sand-gravel mixtures, single size hard rock fill	0.30 to 0.40	17 to 22
—Silty sand, gravel or sand mixed with silt or clay	0.30	17
—Fine sandy silt, nonplastic silt	0.25	14
Various structural materials:		
—Masonry on masonry, igneous, and metamorphic rocks		
• Dressed soft rock on dressed soft rock	0.70	35
• Dressed hard rock on dressed soft rock	0.65	33
• Dressed hard rock on dressed hard rock	0.55	29
—Masonry on wood (cross grain)	0.50	26
—Steel on steel at sheet pile interlocks	0.30	17

face walls of counterfort and buttress walls shall be designed as fixed or continuous beams. The face walls (or stems) shall be securely anchored to the supporting counterforts or buttresses by means of adequate reinforcement.

Wall stems shall be designed for combined axial load (including the weight of the stem and friction due to backfill acting on the stem) and bending due to eccentric vertical loads, surcharge loads and earth pressure.

5.5.6.3 Counterforts and Buttresses

Counterforts shall be designed as rectangular beams. In connection with the main tension reinforcement of counterforts, there should be a system of horizontal and vertical bars or stirrups to anchor the face walls and base slab to the counterfort. These stirrups should be anchored as near to the outside faces of the face walls, and as near to the bottom of the base slab as practicable.

5.5.6.4 Reinforcement

Except in gravity walls, not less than 81 mm^2 (⅛ square inch) of horizontal reinforcement per 0.3 meter (1 foot) of height shall be provided near exposed surfaces not otherwise reinforced to resist the formation of temperature and shrinkage cracks.

The reinforcement in each construction panel (i.e., between vertical construction joints) of wall with height varying uniformly from one end to another, shall be designed for the loading condition acting at one-third of the panel length from the high end of the panel. If practical, the thickness of the footings shall be maintained constant in each panel or in each group of panels. The width of the footings, however, may vary according to the height of the wall as required by design.

Tension reinforcement at the bottom of the heel shall be provided if required during the construction stage prior to wall backfill. The adequacy of the reinforcement shall be checked due to the dead load of the stem and any other vertical loads applied to the stem prior to backfilling.

Reinforcement in wall and abutment stems shall be extended a minimum distance equal to the effective depth of the section or 15 bar diameters, whichever is greater, but not less than 0.3 meter (1 foot) beyond the point at which computations indicate reinforcement is no longer needed to resist stress.