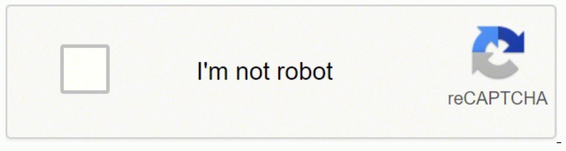

Next

All aashto standards free

Designation: B 265 – 03

Standard Specification for Titanium and Titanium Alloy Strip, Sheet, and Plate[1]

This standard is issued under the fixed designation B 265; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification[2] covers annealed titanium and titanium alloy strip, sheet, and plate as follows:

1.1.1 Grade 1—Unalloyed titanium,

1.1.2 Grade 2—Unalloyed titanium,

1.1.3 Grade 3—Unalloyed titanium,

1.1.4 Grade 4—Unalloyed titanium,

1.1.5 Grade 5—Titanium alloy (6 % aluminum, 4 % vanadium),

1.1.6 Grade 6—Titanium alloy (5 % aluminum, 2.5 % tin),

1.1.7 Grade 7—Unalloyed titanium plus 0.12 to 0.25 % palladium,

1.1.8 Grade 9—Titanium alloy (3.0 % aluminum, 2.5 % vanadium),

1.1.9 Grade 11—Unalloyed titanium plus 0.12 to 0.25 % palladium,

1.1.10 Grade 12—Titanium alloy (0.3 % molybdenum, 0.8 % nickel),

1.1.11 Grade 13—Titanium alloy (0.5 % nickel, 0.05 % ruthenium),

1.1.12 Grade 14—Titanium alloy (0.5 % nickel, 0.05 % ruthenium),

1.1.13 Grade 15—Titanium alloy (0.5 % nickel, 0.05 % ruthenium),

1.1.14 Grade 16—Unalloyed titanium plus 0.04 to 0.08 % palladium,

1.1.15 Grade 17—Unalloyed titanium plus 0.04 to 0.08 % palladium,

1.1.16 Grade 18—Titanium alloy (3 % aluminum, 2.5 % vanadium, 0.04 to 0.08 % palladium),

1.1.17 Grade 19—Titanium alloy (3 % aluminum, 8 % vanadium, 6 % chromium, 4 % zirconium, 4 % molybdenum),

1.1.18 Grade 20—Titanium alloy (3 % aluminum, 8 % vanadium, 6 % chromium, 4 % zirconium, 4 % molybdenum, 0.04 to 0.08 % palladium),

1.1.19 Grade 21—Titanium alloy (15 % molybdenum, 3 % aluminum, 2.7 % niobium, 0.25 % silicon),

1.1.20 Grade 23—Titanium alloy (6 % aluminum, 4 % vanadium with extra low interstitial elements, ELI),

1.1.21 Grade 24—Titanium alloy (6 % aluminum, 4 % vanadium plus 0.04 % to 0.08 % palladium,

1.1.22 Grade 25—Titanium alloy (6 % aluminum, 4 % vanadium plus 0.3 % to 0.8 % nickel and 0.04 % to 0.08 % palladium),

1.1.23 Grade 26—Unalloyed titanium plus 0.08 to 0.14 % ruthenium,

1.1.24 Grade 27—Unalloyed titanium plus 0.08 to 0.14 % ruthenium,

1.1.25 Grade 28—Titanium alloy (3 % aluminum, 2.5 % vanadium plus 0.08 to 0.14 % ruthenium),

1.1.26 Grade 29—Titanium alloy (6 % aluminum, 4 % vanadium with extra low interstitial elements, ELI) plus 0.08 to 0.14 % ruthenium,

1.1.27 Grade 30—Titanium alloy (0.3 % cobalt, 0.05 % palladium),

1.1.28 Grade 31—Titanium alloy (0.3 % cobalt, 0.05 % palladium),

1.1.29 Grade 32—Titanium alloy (5 % aluminum, 1 % tin, 1 % zirconium, 1 % vanadium, 0.8 % molybdenum),

1.1.30 Grade 33—Titanium alloy (0.4 % nickel, 0.015 % palladium, 0.025 % aluminum, 0.15 % chromium),

1.1.31 Grade 34—Titanium alloy (0.4 % nickel, 0.015 % palladium, 0.025 % aluminum, 0.15 % chromium),

1.1.32 Grade 35—Titanium alloy (4.5 % aluminum, 2 %

ACI STRUCTURAL JOURNAL TECHNICAL PAPER

Title no. 103-S70

Evaluation of AASHTO-LRFD General Procedure for Torsion and Combined Loading

by Khaldoun N. Rahal

The general procedure for torsion design in the AASHTO-LRFD is based on the general method, which is a simplification of the equations of the modified compression field theory. This paper presents an evaluation of this procedure by comparing the author's results with available test data on beams subjected to various load combinations such as pure torsion, combined torsion and bending, combined torsion, bending and shear, and combined torsion and axial compression. Typical interaction diagrams between torsion, shear and bending, and axial load are also presented. The comparison shows that the method generally provides conservative results and accurate representations of the interaction between torsion and the other stress resultants. The strength of over-reinforced high-strength concrete beams (failing by crushing of the concrete before yielding of the reinforcement) can be over-estimated, however, unless the concrete strength is limited to 70 MPa (10,000 psi) in the code equation used to check crushing.

Keywords: beams; bending; reinforced concrete; shear; strength; torsion.

INTRODUCTION

The current AASHTO LRFD Specifications[1] allow two different procedures for the design of concrete beams subjected to torsion and shear. The first is the simplified procedure for nonprestressed members, which is based on the traditional 45-degree truss model for both shear and torsion with a concrete contribution modification to the shear resistance based on a $0.167\sqrt{f'_c}$ MPa ($2\sqrt{f'_c}$ psi) shear stress. The second, named the general procedure, is based on the general method (GM),[2,3] which is a simplification of the modified compression field theory (MCFT). The GM also allows a concrete and steel contribution to the shear resistance, and only a steel contribution to the torsional resistance. Unlike the first procedure, however, the GM is based on a variable angle truss model, and a variable concrete contribution stress depending on numerous factors (such as prestressing, axial force, bending moment, and amount of longitudinal reinforcement). It also unifies the design approach to nonprestressed, partially prestressed, and fully prestressed concrete beams subjected to torsion and shear in combination with axial forces and bending moments. It is to be noted that the GM is also the basis of the alternative design procedure for shear and torsion in the current Canadian CSA-A23.3 building code.[4] The method was originally developed for shear and was extended to be applicable for the case of torsion. The background to the development of this method was given by Rahal and Collins.[5]

The GM has been extensively verified for the case of shear combined with bending and axial load.[2-5] A previous study[2] on 528 specimens subjected to shear, bending, and axial load reported an average of observed to calculated strength of 1.39 and a coefficient of variation of 19.7%. The GM, however, has not been validated for the cases of pure torsion and torsion combined with bending, shear, and axial load.

RESEARCH SIGNIFICANCE

This paper presents an evaluation of the GM for the cases of pure torsion and torsion combined with bending, shear, and axial compression. The calculations of the method are checked against 160 test data available in the literature. The performance of the method is also compared with its performance for the case of shear combined with bending moment and axial loads, which was reported in a previous study. In addition, the paper gives general three-dimensional interaction surfaces for reinforced concrete sections subjected to combined torsion, shear and bending, and combined torsion, shear, and axial load.

THE GENERAL METHOD

To clarify this evaluation, the paper briefly discusses the provisions of the GM that are pertinent to the evaluation. The resistance and material factors are not shown in the equations, and, consequently, the factored terms are replaced with the applied or nominal terms. Figure 1 shows some of the geometrical properties referred to in this section.

Strength equations

This method assumes that transverse steel contributes to both the shear and torsional resistance, while concrete contributes only to the shear resistance of the section. The shear resistance V_n at a section is given by

$$V_n = V_c + V_s + V_p \quad (1)$$

Fig. 1—Details and shear flow zones in two typical cross sections.

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MS No. 04-320 received October 4, 2004, and reviewed under Institute publication policies. Copyright © 2006, American Concrete Institute. All rights reserved, including the making of copies unless permission is obtained from the copyright proprietors. Pertinent discussion including author's closure, if any, will be published in the July-August 2007 *ACI Structural Journal* if the discussion is received by March 1, 2007.

In the case of welded end connections, they shall be designed for the vertical loads and the end-bending moment resulting from the deflection of the members. Except on urban expressways, a pedestrian walkway may be separated from an adjacent roadway by a traffic 2.7.1.2.1 The heights of rails shall be measured relative to the reference surface which shall be the top of the roadway, the top of the future overlay if resurfacing is anticipated, or the top of curb when the curb projection is greater than 9 inches from the traffic face of the railing. For o single lacing bracing members, the limits shall be Y ~for and Y75 for double lacing. For homogeneous girders, R shall always be taken equal to l .O. .603 ..... 85 4.6.5.3.3.1 Rock Stratification . 510 PerformanceTest.....511 Proof Test ..... Jensen; ~ulletin304. Minimum Thickness Requirements ..... 332 Design Slip Resistance for Slip-Critical Connections (Slip Resistance per Unit of Bolt Area, +F. If the wall is designed for at-rest earth pressure conditions, the deflections in Table 5.5.2A do not need to be considered. .286 FLOOR SYSTEM . 10.23.2.2 Minimum Size of Fillet Welds 10.21.8 The lateral bracing of compression chords preferably shall be as deep as the chords and effectively connected to both flanges. If heavy scour is expected, consideration shall be given to designing the portion of the shaft that would be exposed as a column. 228 SPAN LENGTH .....228 FRAMES AND CONTINUOUS CONSTRUCTION . 78 4.6.1.3 Construction . Other widely accepted and published design methods for calculation of reinforcement loads may be used at the discretion of the wall owner or the approving agency. '"' g adal force whose length between ex'In connections r treme fastenersmeasured parallel to the Linc of force exQedsSOinches. 10.25.5.1 Pins shall be of sufficient length to secure a full bearing of all parts connected upon the turned body of the pin. .89 Influence Coefficient for Elastic Uplift Displacement of Rock-Socketed Drilled Shafts, Modiied after Pells and nmer(1979) ..... 207 Shearstrength .....207 Shear Strength Provided by Concrete .....208 Shear in Beams and One-way Slabs and Footings . .598 598 Size ..... 10.32.3.2.3 Paint, used on the faying surfaces of connections specified to be slip-critical, shall be qualified by test in accordance with "Test Method to Determine the Nominal Slip Resistance for Slip-Critical Connections (Slip Resistance per Unit of Bolt Area, F,, ksi) Hole and Direction of Load Application Any Direction Standard Oversized and Short Slot Transverse Parallel Long Slots Long Slots AASHTO AASHTO AASHTO AASHTO AASHTO M 164 M 253 M 164 M 253 M 164 M 253 (ASTM (ASTM (ASTM (ASTM (ASTM Contact Surface of Bolted Parts A 325)' A 490) A 325)' A 490) A 325)' A 490) Claw A (Slip Coefficient 0.33) Clean mill scale and blastcleaned surfaces with Class A coatingsb Claw B (Slip Coefficient 0.50) Blast-cleaned surfaces and blast-cleaned surfaces with Class B coatingsb Claw C (Slip Coefficient 0.33) Hot-dip galvanized surfaces and roughened by wire brushing after galvanizing AASHTO AASHTO M 164 M 253 (ASTM A 325)' (ASTM A 490) 15 19 13 16 11 13 9 11 23 29 19 24 16 20 14 17 15 19 13 16 11 13 9 11 "The tensile strength of M 164 (A325)bolts decreases for diameters greater than 1 inch. ,179 SECTION 74UBSTRUCTURES Figure 7.5.4A Limiting Values of Differential Settlement Based on Field Surveys of Simple and Continuous Span Structures of Various Span Lengths, Moulton, et al. Joints in abutments shall be located approximately midway between the longitudinal members bearing on the abutments. 10.19.3 End Connections of Diaphragms and Cross Frames The maximum induced stresses, I?, in the bottom flange of each girder in the system can be computed from the following: where: R = [0.2272L - 111si2I3 when no bottom lateral bracing is provided R = [0.059L- 0.641 s,"~ when bottom lateral bracing is provided 10.19.3.2 The end connections for diaphragms or cross frames in straight rolled-beam and plate-girder bridges shall be designed for the calculated member loads. Load Factor Design-A design method in which safety provisions are incorporated by separately accounting for uncertainties relative to load and resistance. Normalized Response Spectra .....C.45 Ground Motion Spectra for A = 0.4 .....C.46 Ground Motion Spectra for A = 0.4 .....C.46 Comparison of Free Field Ground Motion Spectra and Lateral Design Force Coefficients . 267 . 11: Reinforced Concrete," Journal of Structural Engineering, ASCE, Vol. Not all of these factors will have a significant effect on all geosynthetic products. .662 Foundation ..... .625 Fabrication of PTFE ..... 591 591 Weather Conditions ..... -487 . For d~scont~nuous rernforcement r n ~ r f a o ef r r c t l o n engl* t i e the lower of Ten. Stability of temporary construction slopes needed to construct the wall shall also be evaluated. Plain Elastomenc Pads . For relatively thick facings, such as segmental concrete block facings, the dead weight of the facing may also provide a significant contribution to the capacity of the wall system. 312 10.39.7 Access and Drainage ..... The dimensional units provided with each notation are presented for illustration only to demonstrate a dimensionally correct combination of units for the wall design procedures presented herein. 91 Apparatus for measuring movements. 4.4.7 Geotechnical Design on Soil Spread footings on soil shall be designed to support the design loads with adequate bearing and structural capacity, and with tolerable settlements in conformance with Articles 4.4.7 and 4.4.11. 308 10.39.4.2 Compression Flanges Unstiffened ..... 337 SECTION 1243OIL-CORRUGATED METAL STRUCTURE INTERACTION SYSTEMS GENERAL ..... 77 4.5.20 4.5.20.1 Size and Shape . The revised Article 10.50.1.2.1 also states that the resulting Rbfactor be distributed to the top flange and concrete deck in proportion to their relative stiffness. - - T, Tm,, Re Where To Te, = 8, = T m l Re (FS) = Tult (FSNRF) -. b = the overall width of the box, d = the overall depth of the box, t = the thickness of either web, tf = the thickness of either flange. C10.50.1.2 to moments whereas it does apply to stresses. 330 Effective Length ..... 588 589 Placement ..... 5.8.8.1 Design of Stiff or Rigid Concrete, Steel, and Timber Facings Facing elements shall be structurally designed in accordance with Sections 8, 10, and 13 for concrete, steel, and timber facings, respectively. Greater depths may be required where warranted by The following notations apply for design of retaining walls: A = Acceleration coefficient (dim); (See Article A, = Reinforcement area corrected for corrosion 5.8.9.1) losses (d); (See Article 5.8.6) 118 A, b bf B B' C Cf CR, CR,, C, d Di D* e, e' E, En ER f F* Fp F, F1 F2 HIGHWAY BRIDGES = Maximum wall acceleration coefficient at the centroid (dim); (See Article 5.8.9.1) = Width of discrete wall backfill element (m); (See Article 5.8.6) = Width of vertical or horizontal concentrated dead load (m); (See Article 5.8.12.1) = Total base width of wall, including facing elements (m); (See Article 5.5.5) = Effective base width of retaining wall foundation (m); (See Article 5.8.3) = Overall reinforcement surface area geometry factor (dim); (See Article 5.8.5.2) = Distance from back of wall facing to front edge of footing or other concentrated surcharge load (m); (See Article 5.8.12.1) = A reduction factor to account for reduced connection strength resulting from pullout of the connection (dim); (See Article 5.8.7.2) = A reduction factor to

account for reduced ultimate strength resulting from rupture of the connection (dim); (See Article 5.8.7.2) = Soil coefficient of uniformity (dim); (See Article 5.8.5.2) = Distance from back of wall face to center of concentrated dead load (m); (See Article 5.8.12.1); also, the effective depth relative to stem of concrete semi-gravity walls for calculation of sliding resistance (m); (See Article 5.5.6.1) = Effective width of applied load at depth within or behind wall due to surcharge (m); (See Article 5.8.12.1) = Reinforcement bar diameter corrected for corrosion losses (mm); (See Article 5.8.6) = Eccentricity of forces contributing to bearing capacity (m); (See Articles 5.8.3 and 5.8.12.1) = Thickness of metal reinforcement at end of service life (mm); (See Article 5.8.6) = Nominal thickness of steel reinforcement at construction (mm); (See Article 5.8.6.1.1) = Equivalent sacrificial thickness of metal expected to be lost by uniform corrosion during service life of reinforcement (mm); (See Article 5.8.6.1) = Friction factor (dim); (See Article 5.5.2) = Pullout resistance factor (dim); (See Article 5.8.5.2) = Lateral force resulting from &Anv (kN/m); (See Article 5.8.12.1) = Yield strength of the steel (kN/mm2); (See Article 5.8.6.1.1) = Active lateral earth pressure force for level backfill conditions (kN/m); (See Article 5.8.2) = Lateral earth pressure force due to traffic or other continuous surcharge (kN/m); (See Article 5.8.2) = Active lateral earth pressure force (kN/m); (See Article 5.8.2) = Resultant active lateral earth pressure force (kN/m); (See Article 5.8.2) FS = Factor of safety (dim); (See Article 5.5.5) FSoT = Factor of safety against overturning (dim); (See Article 5.8.2) FSpo = Safety factor against pullout (dim); (See Article 5.8.5.2) FSsL = Factor of safety against sliding (dim); (See Article 5.8.2) Fv = Vertical component of active lateral earth pressure force (kN/m); (See Article 5.8.2) = Distance to center of gravity of a modular block facing unit, including aggregate fill, measured from the front of the unit (m); (See Article 5.8.7.2) h = Equivalent height of soil representing surcharge pressure or effective total height of soil at back of reinforced soil mass (m); (See Article 5.8.2) = Vertical distance Fp is located from bottom of h, wall (m); (See Article 5.8.12.1) H = Design wall height (m); (See Article 5.8.12.1) H1 = Equivalent wall height (m); (See Article 5.8.2) Hu = Effective wall height (m); (See Article 5.8.7.1) Hh = Hinge height for block facings (m); (See Article 5.8.7.2) Hc = Facing unit height (m); (See Article 5.8.7.2) H, = Height of water in backfill above base of wall (m) i = Average slope of broken back soil surcharge (deg.); (See Article 5.8.2) ib = Inclination of wall base from horizontal (deg); (See Article 5.8.7.2) kh = Horizontalseismic coefficient (dim); (See Article 5.8.9.1) kv = Vertical seismic coefficient (dim); (See Article 5.8.9.1) K = Earth pressure coefficient (dim); (See Article 5.5.2) Kae = Total Mononobe-Okabe seismic lateral earth pressure coefficient (dim); (See Article 5.8.9.1) AK, = Dynamic increment of the Mononobe-Okabe seismic lateral earth pressure coefficient (dim); (See Article 5.8.9.1) Kd = active earth pressure coefficient for the soil within the MSE wall reinforcement soil zone (dim) (See Article 5.8.4.1) Ka = Active earth pressure coefficient (dim); (See Article 5.5.2) K, = At-rest earth pressure coefficient (dim) (See Article 5.5.2) PH = DIVISION I. 36e Table 10.32.3B, footnote g.) 10.32.3.1 All bolts except high-strength bolts, tensioned to the requirements of Division II, 4.11.4.4 Loss of Overall Stability The overall stability of slopes in the vicinity of foundations and foundation soil or rock, shall be evaluated for footings located on or near a slope using applicable factored load combinations in Article 3.22 and a performance factor of 0.75. 29 Static Ice Pressure .... 689 PAYMENT . 416 Embankment Beddings. Has No Length End d W/C Category 6 (One box spsca) P FIGURE 10.3.1C Illustrative Examples I WELD CONDITION CAT- -o- . 383 MECHANICAL CONNECTIONS .... DIST. 10.34.2.2.9 legs of angles 6 inches or greater in width, connected to web plates, shall have two lines of HIGHWAY BRIDGES 296 10.34.2.2.9 fasteners. OF NY AND NJ, Joseph J. 569 Galvanizing .... 592 SECTION 15-CONCRETE BLOCK AND BRICK MASONRY Table 15.1 Grouting Limitations .... 605 SECTION 16-TIMBER STRUCTURES Table 16.1 Typical Dimensions of Timber Connectors (dimensions in inches) .... 261 Stress Cycles .... For stable ground masses, the final distribution and magnitude of lateral earth pressure on a completed anchored wall with two or more levels of anchors constructed from the top down may be computed using the apparent earth pressure distribution developed for this purpose. To exceed this upper bound, it is felt that additional specification requirements would need to be inserted to directly control local web bend-buckling under the fatigue loading. Additional Requirements for Foundations for Seismic Performance Category D ....470 470 Investigation .... b r c k r ~ l l and roundauon m a u r ~ aml ~ t krmroact to dam0 s a a u d r a i l u r a as d a s c r ~ b a din h r t ~ c l a5.22.3. J 1 FIGURE 5.5.5A Design Criteria for Rigid Retaining Walls, (Coulomb Analysis) HIGHWAY BRIDGES - -- --- - - - - TABLE 5.5.2B Ultimate Friction Factors and Friction Angles for Dissimilar Materials, After U.S. Department of the Navy (1982) Interface Materials Mass concrete or masonry on the following foundation materials: -Clean sound rock -Clean gravel, gravel-sand mixtures, coarse sand -Clean fine to medium sand, silty medium to coarse sand, silty or clayey gravel -Clean fine sand, silty or clayey fine to medium sand -Fine sandy silt, nonplastic silt -Very stiff and hard residual or preconsolidated clay -Medium stiff and stiff clay and silty clay Steel sheet piles against the following soils: -Clean gravel, gravel-sand mixtures, well-graded rock fill with spalls -Clean sand, silty sand-gravel mixtures, single size hard rock fill -Silty sand, gravel or sand mixed with silt or clay -Fine sandy silt, nonplastic silt Formed concrete or concrete sheet piling against the following soils: -Clean gravel, gravel-sand mixtures, well-graded rock fill with spalls -Clean sand, silty sand-gravel mixtures, single size hard rock fill -Silty sand, gravel or sand mixed with silt or clay -Fine sandy silt, nonplastic silt Various structural materials: -Masonry on masonry, igneous, and metamorphic rocks Dressed soft rock on dressed soft rock Dressed hard rock on dressed soft rock Dressed hard rock on dressed hard rock -Masonry on wood (cross grain) -Steel on steel at sheet pile interlocks face walls of counterfort and buttress walls shall be designed as fixed or continuous beams. These proportions are recommended to help ensure that the web is adequately restrained by the flanges to control web bend-buckling. For granular soils or drained cohesive soils, the critical failure surface is typically assumed to be the active failure wedge which is defined by a plane extending upward from the base of the wall at an angle of 45 +'I2 from the horizontal.Longer free lengths may be required for anchors in plastic soils or where critical failure surfaces are defined by planes or discontinuities with other orientations. SECTION 23-MISCELLANEOUS METAL 23.1 23.2 23.3 23.4 23.5 23.6 DESCRIPTION . 10.24.1.7 The effective bearing area of a fastener shall be its diameter multiplied by the thickness of the metal on which it bears. The existing reference to Article 10.48.8.1 is replaced with the correct reference to Article 10.48.8.2 (see similar reference given in Article 10.48.5.2). The thickness of plates and other parts in direct contact with locomotive blast shall be not less than 3/4 inch for cast iron, 3/8 inch for alloy, 1/2 inch for plain asbestos-board, and 7/~6 inch for corrugated asbestos-board. If estimated or actual movements exceed these levels, special analysis andlor measures to limit movements should be considered. -.- .. 5.6.4 Seismic Pressure Refer to Section 6 of Division I-A for guidance regarding the design of flexible cantilevered walls subjected to dynamic and seismic loads. Pratt ARIZONA, F. Ground Anchors .... 42 SECTION AFOUNDATIONS PART A-GENERAL REQUIREMENTS AND MATERTALS GENERAL .... 4.13.3.3.9 Dynamic/Seismic Design Refer to Division I-A for guidance regarding the design of drilled shafts subjected to dynamic and seismic loads. For reinforcements connected to the facing through embedment between facing elements using a partial or full friction connection (e.g., segmental concrete block faced walls), the capacity of the connection shall be reduced from T,,, for the backfill reinforcement using the connection strength determined from laboratory tests. Shallow Foundation-A foundation which derives its support by transferring load directly to the soil or rock at shallow depth. .73 .. Struts .... 328 Design of Flange to Web Welds ....328 SHEAR CONNECTORS .... Special Fabrication Requirements for Curved Sliding Bearings . 681 Placing and Finishing .... 307 10.39 COMPOSITE BOX GIRDERS . 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. 587 Skid Resistance . 424 16.6 REINFORCED CONCRETE BOX, CAST-IN-PLACE ....424 Application . 471 Vertical Reinforcement .... 181 Culvert in trench. 13 SECTION ?LOADS Figure 3.7.6A Standard H Trucks . If a railing assembly employs both horizontal and vertical elements, the spacing requirements shall apply to one or the other, but not to both. 10.29.7.1 Pedestals and shoes preferably shall be made of cast steel or structural steel. 593 Hand Cleaning ....593 . 10.25.5 Pins and Pin Nuts 10.27.2.3 Steel filling rings shall be provided, if needed, to prevent lateral movement of eyebars or other members connected on the pin. (b) Flood-frequency curve for site. 10.24.2.2.1 Oversize holes may be used in all plies of connections which satisfy the requirements of Article 10.32.3.2.1 or Article 10.57.3, as applicable. 620 18.4.5.2 Fabric Reinforcement .... Not a part of the A 108 specifications. FIGURE 2.4A Clearance Diagrams for Underpasses (See Article 2.4 for General Requirements.) c I- + NOT LESS THAN 30 FT. For calculations of external stability, the continuous traffic surchargeloads shall be considered to act beyond the end of the reinforced zone as shown in Figure 5.8.2.A. Overall stability analyses shall be performed in accordance with Article 5.2.2.3. Additionally for MSE walls with complex geometries, or where walls support steep, infinite, sloping surcharges (i.e., a slope greater than 2H in length as shown in Figure 5.8.2C and a slope of 2H: 1V or steeper), 143 compound failure surfaces which pass through a portion of the reinforced soil mass as illustrated in Figure 5.8.2D shall be analyzed, especially where the wall is located on sloping or soft ground where overall stability is marginal. 10.17.4.3 Horizontal diagonal bracing shall be placed in all towers having more than two vertical panels, at alternate intermediate panel points. 687 Thermoplastic Pipe .... 4.13.3.3.3 Estimation of Drilled-Shaft Capacity in Cohesionless Soils The ultimate bearing capacity of drilled shafts in cohesionless soils shall be estimated using applicable methods, and the factored capacity selected using judgment, and any available experience with similar conditions. 4.2.2.2 Settlement The settlement of foundations may be determined using procedures described in Articles 4.4,4.5, or 4.6 for service load design and Articles 4.11, 4.12, or 4.13 for strength design, or other generally accepted methodologies. 409 16.4.2.2 Reinforcement .... Parapets designed with sloping traffic faces intended to allow vehicles to ride up them under low angle contacts shall be at least 2 feet 8 inches in height. and Bronze or Copper Alloy . Design Loads 401 Materials . Horizontal movements resulting from outward rotation of the wall or resulting from the development of internal equilibrium between the loads applied to the wall and the internal structure of the wall must be limited to prevent overstress of the structural wall facing and to prevent the wall face batter from becoming negative. For design purposes, it shall be assumed that wheel loads are positioned to generate the maximum tensile stresses at the back of the backwall when combined with stresses caused by the backfill. Part C STRENGTH DESIGN METHOD LOAD FACTOR DESIGN Note to User: Article Number 4.7 has been omitted intentionally. 195 COMPUTATION OF DEFLECTIONS .... In 2002, Section 18, "Soil-Thermoplastic Pipe Interaction Systems," Division I, became Section 17. Inquiries as to the intent or application of the specifications should be sent to the same address. C10.38.5.1 Horizontal Shear C10.39 COMPOSITE BOX GIRDERS C10.38.5.1.1 Fatigue C10.39.4 Design of Bottom Flange Plates In the design of shear connectors for fatigue, this revision requires that the statical moment Q and moment of inertia I (used to compute the shear range) be calculated using the full composite section (including the transformed concrete deck) along the entire length of the girder if the transformed concrete area is considered to be fully effective for negative moment in computing the longitudinal range of stress (as permitted under the provisions of revised Article 10.3.1 in ASD and revised Article 10.58.1 in LFD). strips) use 1an P IS the r o l l / r o l l rernforcements (e. 10.29.1.2 Spans of less than 50 feet may be arranged to slide upon metal plates with smooth surfaces and no provisions for deflection of the spans need be made. Use of Special Anchorage Devices . 496 Pile Cut-off .... Footing excavations in nonresistant, easily weathered moisture sensitive rocks shall be protected from weathering immediately after excavation with a lean mix concrete or other approved materials. .92 General .... .346 Steel Spiral Rib Pipe and Pipe-Arch RequirementsAASHTO M 218 .... Corrosion protection shall be applied in accordance with Section 6 of Division 11--Ground Anchors. .- . 411 16.4.4.2.1 Earth Loads and Pressure Distribution .... 404 Criteria .... However, as indicated, the resulting pitch between points of dead-load contraflexureis not to exceed the maximum pitch specified in Article 10.38.5.1. Shear connectors are designed for shear; the design moment in the girder is not relevant. 28 UPLIFT .... Attachment of PTFE . These forces are illustrated in Figure where, Pi,is the inertial force caused by acceleration of the reinforced backfill and Pisis the inertial force caused by acceleration of the sloping soil surcharge above the reinforced backfill, with the width of mass contributing to P, equal to 0.5H2.PIRacts at the combined centroid of Pi,and Pis.This is illustrated in Figure 5.8.9.1A. Drilled shafts are also commonly referred to as caissons, drilled caissons, bored piles or drilled piers. .558 . Reference 11 provides some guidance in this regard. The current references to Articles 10.48 and 10.49 are replaced with the more correct references to Articles 10.50.2.1 or 10.50.2.2, as applicable, for the computation of the maximum bending strength. 499 WorkingDrawings .... 532 Sequence of Placement .... 10.25.5.2 Members shall be restrained against lateral movement on the pins and against lateral distortion due to the skew of the bridge. Highway and railroad crossings should provide for possible future works such as road widening. and 12 times the plate thickness but less than 4 in. 4 FOR NORMALLY CONSOLIDATED CLAY (21 4 (3) VALUE OF 0.4 SHOUU) BE USED A e 4 0.50 H a 4 -fl CLAYS m LESS :I FORTHAN OVERCONSOLIDATED 0.25 0.25 H STIFF TO (4) HARD CLAY K ~ TAN^ = (45 12' K a = I - m L2qUIyH) BOTNOT 0.75H 0.25 fO 1.0 TSF) "' NOTES v 0.25 H FOR LONG-TERM EXCAVATIONS ; VALUES BETWEEN 0.4 AND 0.2 MAY BE USED FOR SHORT-TERM CONDITIONS. 488 SECTION "DRIVEN FOUNDATION PILES DESCRIPTION ....489 MATERIALS .... 540 Water .... The term 'properly braced' infers that the bracing is sufficient to resist lateral-torsionalbuckling of the member according to the revised language specified in Article 10.48.1.1 (see below). 1.9 UTILITIES Section 2 GENERAL FEATURES OF DESIGN 2.1 GENERAL 2.2 STANDARD HIGHWAY CLEARANCESGENERAL 2.1.1 Notations 2.2.1 Navigational Af = area of flanges (Article 2.7.4.3) b = flange width (Article 2.7.4.3) C = modificationfactor for concentrated load, P, used in the design of rail members (Article 2.7.1.3.1) D = clear unsupported distance between flange components (Article 2.7.4.3) d = depth of W or I section (Article 2.7.4.3) Fa = allowable axial stress (Article 2.7.4.3) Fb = allowable bending stress (Article 2.7.4.2) F, = allowable shear stress (Article 2.7.4.2) F, = minimum yield stress (Article 2.7.4.2) fa = axial compression stress (Article 2.7.4.3) h = height of top rail above reference surface (Figure 2.7.4B) L = post spacing (Figure 2.7.4B) P = railing design loading = 10 kips (Article 2.7.1.3 and Figure 2.7.4B) P' = railing design loading equal to P, PI2 or PI3 (Article 2.7.1.3.5) t = flange or web thickness (Article 2.7.4.3) w = pedestrian or bicycle loading (Articles 2.7.2.2 and 2.7.3.2) 2.1.2 Width of Roadway and Sidewalk The width of roadway shall be the clear width measured at right angles to the longitudinal center line of the bridge between the bottoms of curbs. 68 Development Length .... Geosynthetic Reinforcements . Retaining walls shall be designed to provide adequate structural capacity with acceptable movements, adequate foundation bearing capacity with acceptable settlements, and acceptable overall stability of slopes adjacent to walls. 531 Mixing and Placing .... E MC Ma M, M, M n ~ Mu M, Mw M,, M, M, n N Nc HIGHWAY BRIDGES = moment to be used for design of compression member, N.mm (Article 8.16.5.2.7) = cracking moment, N-mm (Article 8.13.3) = nominal moment strength of a section, N-mm = nominal moment strength of a section in the direction of the x axis, N-mm (Article 8.16.4.3) = nominal moment strength of a section in the direction of the y axis, N-mm (Article 8.16.4.3) = factored moment at section, N-rnm = factored moment component in the d i i i o n of the x axis, N-mm (Article 8.16.4.3) = factored moment component in the direction of the y axis, Namm (Article 8.16.4.3) = value of smaller end moment on compression member due to gravity loads that result in no appreciable sidesway calculated by conventional elastic frame analysis, positive if member is bent in single mature, negative if bent in double curvature, N-mm (Article 8.16.5.2.4) = value of larger end moment on compression member due to gravity loads that result in no appreciable sidesway calculated by conventional elastic frame analysis, always positive, N-mm (Article 8.16.5.2) = value of larger end moment on compression member due to lateral loads or gravity loads that result in appreciable sidesway, defined by a deflection A, greater than P,/1500, calculated by conventional elastic frame analysis, always positive, N-mm (Article 8.16.5.2) = modular ratio of elasticity = E,/Ec, nondimensional (Article 8.15.3.4) = design axial load normal to cross section occurring simultaneously with V to be taken as positive for compression, negative for tension and to include the effects of tension due to shrinkage and creep, N (Articles 8.15.5.2.2and 8.15.5.2.3) = design tensile force applied at top of bracket of corbel acting simultaneously with V, to be taken as positive for tension, N (Article 8.15.5.8) N" NW pb PC PO pn pm pw ,P PU r r s SW S V v VC VC Va Vh 727 = factored axial load normal to the cross section occuning simultaneously with V, to be taken as positive for compression, negative for tension, and to include the effects of tension due to shrinkage and creep, N (Article 8.16.6.2.2) = factored tensile force applied at top of bracket or corbel acting simultaneously with Vu, to be taken as positive for tension, N (Article 8.16.6.5) = nominal axial load strength of a section at balanced strain conditions, N (Article 8.16.4.2.3) = critical load, N (Article 8.16.5.2.7) = nominal axial load strength of a section at zero eccentricity, N (Article 8.16.4.2.1) = nominal axial load strength at given eccentricity, N = nominal axial load strength corresponding to M,, with bending considered in the direction of the x axis only, N (Article 8.16.4.3) = nominal axial load strength corresponding to M,, with bending considered in the direction of the y axis only, N (Article 8.16.4.3) = nominal axial load strength with biaxial loading, N (Article 8.16.4.3) = factored axial load at given eccentricity, N = radius of gyration of cross section of a compression member, mm (Article 8.16.5.2.2) = base radius of deformed reinforcing bar, mm (Article 8.16.8.3) = spacing of shear reinforcement in direction parallel to the longitudinal reinforcement, mm (Article 8.19.1.2) = spacing of wires to be developed or spliced, mm (Article 8.30.1.2) = span length, mm = design shear force at section, N (Article 8.15.5.1.1) = design shear stress at section, MPa (Article 8.15.5.1.I) = nominal shear strength provided by concrete, N (Article 8.16.6.1) = permissible shear stress canied by concrete, MPa (Article 8.15.5.2) = design horizontal shear stress at any cross section, MPa (Article 8.15.5.5.3) = permissible horizontal shear stress, MPa (Article 8.15.5.5.3) HIGHWAY BRIDGES 728 v, = nominal shear strength, vah = vs = VU = We = = YI z = a (alpha)= g = (beta)= Be Bd = = N (Article 8.16.6.1) nominal horizontal shear strength, N (Article 8.16.6.5.3) nominal shear strength provided by shear reinforcement, N (Article 8.16.6.1) factored shear force at section, N (Article 8.16.6.1) mass density of concrete, kg1m3 distance from centroidal axis of gross section, neglecting reinforcement, to extreme fiber in tension, mm (Article 8.13.3) quantity limiting distribution of flexural reinforcement, Nlmm (Article 8.16.8.4) angle between inched shear reinforcement and longitudinal axis of member angle between shear-friction reinforcement and shear plane (Articles 8.15.5.4 and 8.16.6.4) ratio of area of reinforcement cut off to total area of reinforcement at the section, nondimensional (Article 8.24.1.4.2) ratio of long side to short side of concentrated load or reaction area; for a circular cmmamed load or reaction area, 8, = 1.0, nondimensional (Articles 8.15.5.6.3 and 8.16.6.6.2) absolute value of ratio of maximum dead load moment to maximum total load moment, always positive, nondimensional APP. 659 WORJCING DRAWINGS .... 2' Rad. The design of rock sockets shall be based on the unconfined compressive strength of the rock mass (C,) or concrete, whichever is weaker (03.C, may be estimated using the following relationship: C, = aECo (4.6.5.3.1-2) Refer to Article 4.4.8.2.2 for the procedure to determine aEas a function of RQD. 10.24.4.3 In angles whose size is not determined by calculated stress, %-inch fasteners may be used in 2-inch legs, %-inch fasteners in 2Kinch legs, %-inchfasteners in 3-inch legs, and 1-inch fasteners in 3%-inchlegs. 76 MinimumArea .... The distribution of soil pressure shall be consistent with properties of the soil and the structure, and with established principles of soil mechanics. IORCES 51- Cetermine the value of x P*/((K -K,,)Y;I for the distribution of net passit: pressure in front of the wall below the dredge line (refer to Table 5 . NCHRP Report 429, HDPE Pipe: Recommended Material Specifications and Design Requirements, Y. 273 Web Splices .... 582 Welding . ... 648 Concrete Slope Paving . C10.53.3 Shear This new article represents the previous Article 10.53.1.4 (Transversely Stiffened Girders), which has been moved here to improve the overall flow of the specification. Suggestions for the improvement of the specifications are welcomed. COATINGS . 184 Partial-Depth Abutment .... 78 4.6.1.5 Shaft Diameter .... 512 Ground Anchor Load Test Acceptance Criteria .... 593 .. Steels meeting the AASIITO quiremenu are p r q d i f ~for i use in welded bridges M270G~36andA709Gr.36arcwuivalenttoM 183andA36 ~270GrMaad~709~~50are&~to~223GrMand~572~r.50 M 270 Gc SOW and A 709 Gr 50W are eauivalent to M 222 and A 588 M 270 GL 70W a d A 709 GL70W are e&ivalent to A 852 M 270 GL 1W100W and A 709 Gr.lWlOOW arc equivalent to M 244 and A 514 For theuse of larger Cbvalues, see Structural Stability Raearch Council Gvidc to Stubiliiy Design Criteriufw Metal Smhrns. All values used for design shall be confirmed by field andlor laboratory testing. 4.6.6.4 Center-to-Center Shaft Spacing The center-to-center spacing of drilled shafts should be 3B or greater to avoid interference between adjacent shafts during construction. An additional revision regarding the placement of longitudinal web stiffeners in yielded portions of the web parallels a similar revision given in a new ASD Article 10.40.2.1.4 (see the earlier discussion on the new Article 10.40.2.1.4). 483 Working Drawings ....483 Design .... this limit, Rbis equal to 1.O. Since Rbhas now been directly included in determining the maximum compression-flange capacity according to new Equation (10-99), this web thickness requirement is no longer necessary since it is implicitly included in the computation of Rbby Equation (10-103b) in Article 10.48.4.1. Instead, the revised article simply refers to the existing overall web thickness limits for symmetric and singly symmetric transversely stiffened girders with and without longitudinal web stiffeners given in subsequent articles. 393 Materials ..... Dewatering or cutoff methods to control seepage shall be used where necessary. For restrained or yielding walls for which the tilting or deflection required to develop active earth pressure is not tolerable (i.e., yielding walls located adjacent to structures sensitive to settlement),lateral earth pressures shall be computed assuming at-rest conditions using the relationships Refer to Figure 5.5.1A for terminology used in the design of rigid gravity and semi-gravity retaining walls. Friction Losses ....; .... They are also effective where deep foundation embedment is required for stability. The resistance due to passive earth pressure in front of the wall shall be neglected unless the wall extends well below the depth of frost penetration, scour or other types of disturbance (e.g., a utility trench excavation in front of the wall). .229 General ....229 Positive Moment Connection at Piers .... 4.6.5.5.1 Shafs in Soil Settlements should be estimated for the design or working load. 4.4.5.4 Piping Piping failures of fine materials through rip-rap or through drainage backfills behind abutments shall be pre- 49 vented by properly designed, graded soil filters or geotextile drainage systems. Language is also inserted at the end of this article to indicate that sections of partially braced members must satisfy the web thickness limits given by Equations (10-104) or (10-log), as applicable, subject to the requirements of Article 10.49.2 or 10.49.3 (with the exception noted below for constructibility-seethe commentary to the revisions to Article 10.61.1). McDonald KANSAS, Kenneth F. .454 . Thus, whenever Equation (10-103b) is applicable to a composite section under positive moment, a modified Rbfactor for the top flange (termed Rb) can be computed as follows: C-131 Essentially, the calculated load-shedding factor to be applied to the effective transformed area is first proportioned to the steel flange and is then used to compute a modified (smaller) load-shedding factor for the flange. (1974) 4.4.8.1.2 DMSION I-DESIGN 63 mass characteristics must be made. ,186 lxxvi CONRNTS Figures SECTION 8-REINFORCED CONCRETE Figure 8.15.5.8 Figure 8.16.4.4.1 Figure 8.16.6.8 Figure 8.29.1 Figure 8.29.4 Untitled .... 531 Heating of Mix .... 13 2.7.3.2.2 The minimum design loading for pedestrian railing shall be w = 50 pounds per linear foot, transversely and vertically, acting simultaneously on each longitudinal member. 314 10.41.1 Wheel Load Contact Area .... 4.6.5.6.1.4 DIVISION I-DESIGN 89 FIGURE 4.6.5.5.2B Influence Coefficient for Elastic Uplift Displacementof Rock-Socketed Drilled Shafts Modified after Pells and 'hrner (1979) 4.6.5.6.1.7 Sloping Ground FIGURE 4.6.5.5.2A Influence Coefficientfor Elastic Settlement of Rock-Socketed Drilled Shafts Modified after Pells and 'hrner (1979) CTC Shaft Spacing for In-line Loading 8B 6B 4B 3B Ratio of Lateral Resistance of Shaft in Group to Single Shaft 1.00 0.70 0.40 0.25 4.6.5.6.1.5 Cyclic Loading The effects of traffic, wind, and other nonseismic cyclic loading on the load-deformation behavior of laterally loaded drilled shafts shall be considered during design. The effect of reduced overburden pressure caused by the downdrag shall be considered in calculating the bearing capacity of the foundation. Intermediate cross frames shall be normal to the main members when the supports are skewed more than 20". 58 4.4.7.2.3 Consolidation Settlement .... .626 Special Fabrication Requirements for Steel Reinforced Elastomeric Bearings and Elastomeric Pads . 106 107 4.13.3.1 Factors Affecting Axial Capacity .... If the lateral bracing satisfies Equation (10-101), the compression-flange capacity is given by a new Equation (10-99) based on a critical flange stress F,,, which depends on the slenderness of the compression flange. For retaining walls over 30 meters (100 feet) in length, the spacing between borings should be 30 meters (100 feet). Time and budget constraints. TABLE 5.7.6.2B Presumptive Ultimate Values of Load Transfer for Preliminary Design of Anchors in Rock Modified after Cheney (1982) Rock Type Granite or Basalt Dolomitic Limestone Soft Limestone Sandstone Slates and Hard Shales Soft Shales Estimated Ultimate Transfer Load (kipsllineal foot) 50 40 30 30 25 10 The required anchor forces shall be determined in accordance with Article 5.7.6.1. The ultimate anchor capacity per unit length may be preliminarily estimated using the guidelines presented in Tables 5.7.6.2A and 5.7.6.2B for soil and rock, respectively. .8. 603 . -36 Case A-Reinforcement Perpendicular to Traffic ....36 Case B-Reinforcement Parallel to Traffic ....36 xi CONTENTS Division I _ A Railing Loads ....36 Slabs Supported on Four Sides . It must be noted that, even if overall stability is satisfactory, special exploration, testing and analyses may be required for bridge abutments or retaining walls constructed over soft subsoils where consolidation andlor lateral flow of the soft soil could result in unacceptable longterm settlements or horizontal movements. 605 MEASUREMENT AND PAYMENT .... 4.11.2 Notations = footing width (in length units) ,,Cw2 Df Dw & = reduced effective footing width (see Article 4.11.4.1.5) (in length units) = soil cohesion (in units of forceAength2) = correction factors for groundwater effect (dimensionless) = depth to footing base (in length units) = depth to groundwater table (in length units) = elastic modulus of rock masses (in units of force/length2) SPT-method CPT-method Load test Pile driving analyzer 0.70 L' = type of load = reduced effective length (see Article Li N = load type i = average value of standard penetration 1 4.11.4.1.5) (in length units) test blow count (dimensionless) N,, Nc,, N,, = modified bearing capacity factors used in analytic theory (dimensionless) = cone resistance (in units of forceAength2) ¶C = ultimate bearing capacity (in units of 9.a forceAength2) = reduction factor due to the effect of load RI inclination (dimensionless) R, = nominal resistance RQD = rock quality designation = span length (in length units) s = undrained shear strength of soil (in units S, of forceAength2) = load factor coefficient for load type i (see Pi Article 4.10.4) = load factor (see Article 4.10.4) Y = total (moist) unit weight of soil (see ArtiY cle 4.11.4.1.1) TABLE 4.10.6-3 Performance Factors for Geotechnical Strength L i t States in Axially Loaded Drilled Shafts Performance Factor Method/SoiCondition Ultimate bearing capacity of s i d e drilled shafts Side resistance in clay a-method (Reese & O'Neill) 0.65 Base resistance in clay Total Stress (Reese & O'Neill) 0.55 Side resistance in sand 1) Touma & Reese 2) Meyerhof 3) Quiros & Reese 4) Reese & Wright 5) Reese & O'Neill See discussion in article 4.13.3.3.3 Base resistance in sand 1) Touma & Reese 2) Meyerhof 3) Quiros & Reese 4) Reese & Wright 5) Reese & O'Neill See discussion in article 4.13.3.3.3 Side resistance in rock Carter & Kulhawy Horvath and Kemey 0.55 0.65 Canadian Geotechnical Society Pressuremeter Method (Canadian Geotechnical Society) 0.50 Load test 0.80 Clav 0.65 a-method (Reese & O'Neill) Belled Shafts (Reese & O'Neill) 0.55 -- - - Base resistance in rock Side resistance and end bearing Block failure Uplift capacity of single drilledI shafts Group uplift capacity Clay 0.50 0.50 Sand 1) Touma & Reese 2) Meyerhof 3) Quiros & Reese 4) Reese & Wright 5) Reese & O'Neill Rock Carter & Kulhawy Horvath & Kemey 0.45 0.55 Load test 0.80 Sand Clay See discussion in section 4.13.3.3.3 4.11.2 DMSION I-DESIGN 6 = differential settlement between adjacent 4) 4)f footings = performance factor = friction angle of soil 4.11.3 Movement Under Serviceability Limit States 4.11.3.1 General Movement of foundations in both vertical settlement and lateral displacement directions shallbe investigated at service limit states. For segmental concrete facing blocks, facing stability calculations shall include an evaluation of the maximum vertical spacing between reinforcement layers, the maximum allowable facing height above the uppermost reinforcement layer, inter-unit shear capacity, and resistance of the facing to bulging. The performance factor for the group uplift capacity calculated as the sum of the individual pile capacities shall be the same as those for the uplift capacity of single piles as given in Table 4.10.6-2. Arch. 331 Division I Division I CONTENTS 10.56.1.1 10.56.1.2 10.56.1.3 10.56.1.4 10.56.2 10.56.3 10.57 10.57.1 10.57.2 10.57.3 10.58 10.58.1 10.58.2 10.58.2.1 10.58.2.2 10.58.3 10.59 10,60 10.61 10.61.1 10.61.2 10.61.3 10.61.4 General .... Lastly, the revised article states that the revised web thickness requirement of Article 10.48.2.1(b) shall apply. A, of each splice plate shall be taken as defined in Article 10.18.2.2.4. As a minimum, the connections for both the top and bottom flange splices shall be proportioned to develop the design force in the flange through shear in the bolts and bearing at the bolt holes, as specified in Table 10.32.3B. ~ a i metal e adjacent to details attached by full or partial T or Rev penetration groove welds when the detail length, L, in the direction of stress, is less than 2 in. 426 Materials .... 588 .. 10.29.3 bearings, this distance shall be measured from the center of the pin. In highly plastic and organic clay, secondary settlements are significant and shall be included in the analysis. 2.7.1.3 Loads 2.7.1.3.1 When the height of the top of the top traffic rail exceeds 2 feet 9 inches, the total transverse load distributed to the traffic rails and posts shall be increased by the factor C. 13 .. or less in. Performance Factors . Cast Iron. 10.24.1 General 282 HIGHWAY BRIDGES 10.24.1.9 In bearing-type connections, pull-out shear in a plate should be investigated between the end of the plate and the end row of fasteners. S shall be the clear span plus one-half thickness of stringer. 611 Mud Sills .... 87 4.6.5.5.2 Shafts Socketed into Rock . Where use of heavy static or vibratory compaction equipment within a distance of about 0.5H behind the wall is anticipated, the effects of backfill com- Wall Rotation, A/H Active Passive Dense Cohesionless Loose Cohesionless Stiff Cohesive Soft Cohesive 0.001 0.004 0.010 0.020 K,, = 1 - sin+' 0.020 0.060 0.020 0.040 (5.5.2-2) When traffic loads are applied within a horizontal distance from the top of the wall equal to one-half the wall height, the lateral earth pressure for design shall be increased by a minimum surcharge acting on the backslope equivalent to that applied by 0.6 meters (2 feet) of soil as described in Article 3.20.3. The surcharge will result in the application of an additional uniform pressure on the back of the wall having a resultant magnitude -sin' k, 5.5.2 (8. 194 COMPRESSION FLANGE WIDTH . The supporting capacity of drilled shafts shall be estimated by static analysis methods (analytical methods based on soil-structure interaction). 505 Unexpected Obstructions .... 4.4.7.1 Bearing Capacity The ultimate bearing capacity (for general shear failure) may be estimated using the following relationshipfor continuous footings (i.e., L > 5B): The allowable bearing capacity shall be determined as: Refer to Table 4.4.7.1A for values of N,, N,, and N,. means of rock anchors, rock bolts, dowels, keys or other suitable means. The sacrificial thickness (i.e., corrosion loss) is computed for each exposed surface as follows, assuming that the soil backfill used is nonaggressive: Galvanization loss Carbon steel loss 15 pmlyear (0.60 milslyear) for first 2 years 4 @year (0.16 milslyear) for subsequent years 12 @year (0.47 milslyear) after zinc depletion These sacrificial thichesses account for potential pitting mechanisms and much of the uncertainty due to data scatter, and are considered to be maximum anticipated losses for soils which are defined as nonaggressive. 341 xxxv xxxvi CONTENTS Division I Buckling .... The upper limit on ulminimum timate strength is taken equal to the tensile strength of a stud shear connector (in ksi), equal to 60,000 psi (refer to Article 11.3.3.1 of Division u), times the cross-sectional area A,, of an individual stud. 5 rOESlON U€tSEN CWESIVE SOIL UO COICRETE* FRCU W T 0 T a E 5.5.1. EFFECTIVE Y([iLE OF IWtEAm FRICTION OF SOIL OR m. lxi ~ . F COEFFICIENT OF CIltCTION I T M E N ULU YO FR)(OITIW T U 5.l.20. 486 General .... 303 10.37.3 10.38 COMPOSITE GIRDERS . Longitudinal drainage on long bridges should be provided by scuppers or inlets which should be of sufficient size and number to drain the gutters adequately. The moments obtained shall be used in designing the center half of the short and long slabs. 517 Weep Holes .... TABLE 5.8.6.1.2B Default and Minimum Values for the Total Geosynthetic Ultimate Limit State Strength Reduction Factor, RF Total Reduction Factor, RF Application -- -- - All applications, but with product specific data obtained and analyzed in accordance with FHWA Publication No. FHWA SA-96-071 "Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines''-Appendix B, and FHWA Publication No. FHWA SA-96-072 "ComsionlDegradation of Soil Reinforcements for MechanicallyStabilized Earth Walls and Reinforced Soil Slopes" Permanent applications not having severe consequences should poor performance or failure occur, nonaggressive soils, and polymers meeting the requirements listed in Table 5.8.6.1.2A. 488 MEASUREMENT AND PAYMENT .... 483 Construction .... EMBEDMENT IN COHESIVE SOIL RETAINING GRANULAR SOIL b. FIGURE 5.8.3B Calculation of Vertical Stress for Bearing Capacity Calculations (for Sloping Backslope Condition) 146 HIGHWAY BRIDGES bility and material type. ACI 318 R, published by the American Concrete Institute. 455 General .... .670 Precast Reinforced Concrete Circular. ; ....176 Bearing Capacity Failure .... bCoatings classified as Class A or Class B include those coatings which provide a mean slip coefficient not less than 0.33 or 0.50, respectively,as determined by Testing Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints. 57 4.4.7.2.2 Elastic Settlement .... 625 Stainless Steel Mating Surface ....625 625 Lubrication .... .89 Combined Axial and Lateral Loading . Risch KENTUCKY, Stephen E. 401 Shear Resisting Mechanism .... The net section of a part is the product of the thickness of the part multiplied by its lea; net width. 10 Geometry .... -10 Loads .... 2 Factors of Safety Spread footings on soil shall be designed for oroUp 1 loadings using a minimum factor of safety (Fs) of 3.0 against a bearing capacity failure. 4.11 SPREAD FOOTINGS 4.11.1 General Considerations 4.11.1.1 General Provisions of this article shall apply to design of isolated footings, and where applicable, to combined footings. The diaphragms shall be designed to resist the full moment and shear produced by the wheel loads which can come on them. For computing shear strength of circular sections, d need not be less than the distance from extreme compression fiber to centroid of tension reinforcement in opposite half of member. The reduced effective area is always concentrically loaded, so that the design bearing pressure on the reduced effective area is always uniform. 4.12.3.3.7~ Single Pile Upliji Capacity The ultimate uplift capacity of a single pile shall be estimated in a manner similar to that for estimating the skin friction resistance of piles in compression in Article 4.12.3.3.2 for piles in cohesive soils and Article 4.12.3.3.3 for piles in cohesionless soils. ~ ~ u'H x-rn SECTION LINE LOAD V a l u e of cH LINE LOAD SECTION PLAN POINT LOAD Value of CH (-)H' QP POINT LOAD FIGURE 5.5.2B Procedure to Determine Lateral Pressure Due to Point and Line Loads, Modified after Terzaghi (1954) paction shall be considered in estimating the lateral earth pressure distribution used for design. 72 Pile Group ....72 Vertical Ground Movement ....72 Negative Skin Friction .... A representative, but not exclusive, listing of problem conditions requiring special consideration is presented in Table 4.2.3A for general guidance. = inch; and psi = pound per square inch. 525 Construction Methods . 5.5.8 Overall Stability Refer to Article 5.2.2.3. 5.6.1 Design Terminology Earth Pressure and Surcharge Loadings Lateral earth pressures shall be estimated assuming wedge theory using a planar surface of sliding defined by Coulomb theory. ter of gravity of the upper rail, but at a height not greater than 54 inches. ,I 2.0 N 9 I TO SCALE 1 1 1 I l l 1 1 1 I l l " I . Welded Splices . 10.20.3 10.22 CLOSED SECTIONS AND POCKETS 10.22.1 Closed sections and pockets or depressions that will retain water, shall be avoided where practicable. 199912000 COMMENTARY Also, near points of dead-load contraflexure, both edges of the web may be in compression when stresses in the steel and composite sections due to moments of opposite sign are accumulated. The slenderness limit no longer needs to be specified as a function of F, since the maximum bending strength of the compression flange is computed based on the actual value of the slenderness in the new Equation (10-99). Galambos, 1998. 326 Lateral Distribution ....327 Webplates ....327 TensionFlanges ....327 Compression Flanges .... 92 Strength Limit States ....92 Strength Requirement .... 294 10.33.2 10.34 PLATE GIRDERS .... .547 ConstructionLoads . 4.4.8.1.3 Factors of Safety ....63 4.4.8.2 Settlement .... 312 10.40.1 Allowable Stresses .... 335 Composite Construction ;.................... where, Wp = Width of Panel; in feet (3.5 5 Wp 5 4.5) L =Length of span for simple span bridges and the length of the shortest span for continuous bridges in feet. -20 Standard Truck and Lane Loads .... C10.36 COMBINED STRESSES Table C10.36A Bending-Compression Interaction Coefficients The current lower limit of 0.4 on the C, coefficient contained in the amplification factor for members under combined bending and axial force comes into effect for end moment ratios less than or equal to -0.5. The C, factor with the lower limit of 0.4 was originally adopted from the work of Austin (Reference 8), who originally intended the factor to apply to lateral-torsional buckling of beams, and not to the determination of second-order in-plane bending strength of beam columns. In 1997, Section 19, "Pot Bearings," Division I, was replaced by Section 14, "Bearings." 5. Hughes NORTHWEST TERRITORIES, John Bowen NOVA SCOTIA, Alan MacRae, Mark Pertus ONTARIO, Vacant SASKATCHEWAN, HervC Bachelu FHWA, Shoukry Elnahal MASS. To the extent possible, the presence and influence of such conditions shall be evaluated as part of the subsurface exploration program. Castings . Coarse Aggregate .... 228 Bridges Composed of Simple-Span Precast Prestressed Girders . 335 Hybrid Beams and Girders .... Pockets which may hold locomotive gases shall be avoided as far as practical. DMSION I-DESIGN 10.6.6 263 TABLE 10.3.1B (Continued) General Condition Kind of Stress Situation Stress Category (See Table Illustrative Example (See Figure 10.3.1A) 10.3.1C) Base metal adjacent to details attached by fillet welds with a transition radius, R, regardless of the detail length: Fillet Welded AttachmentsTransversely Loaded with the Weld in the Direction of Principal StressC f Mechanically Fastened Connections Eyebar or Pin Plates -With the end welds ground smooth (a) Transition radius 2 2 in. When footings support more than one column, pier, or wall, distribution of soil pressure shall be consistent with properties of the foundation materials and the structure, and with the principles of geotechnical engineering. Included are requirements related to the spacing and stiffness of the transverse stiffeners. For undrained loading, cl equals the undrained soil shear strength su,and +, = 0. 7. 394 Geometric Requirements ....394 Elastomeric Disc .....;.................... 108 4.13.3.3.8b Cohesionless Soil .... .411 Equivalent USCS and AASHTO Soil Classifications for SIDD Soil Designations ....C-70 Tie Details in a Rectangular Column .... 10.17.2 Single Bents Single bents shall have hinged ends or else shall be designed to resist bending. 10.30.8.2 Metal Stay-in-Place Forms In skew bridges without end floor beams, the end panel stringers shall be secured in correct position by end struts connected to the stringers and to the main truss or girder. T or Rev -For all transition radii without end welds ground smooth. .548 SECTION 9-REINFORCING STEEL DESCRIPTION ....549 MATERIAL .... Laboratory testing of soil and groundwater samples for sulfates, chloride and pH should be sufficient to assess deterioration potential. 487 General . ., nondim. 4.13 DRILLED SHAFTS 4.13.1 General The provisions of the specifications in Articles 4.6.1 through 4.6.7, with the exception of Article 4.6.5, shall apply to the strength design (load factor design) of drilled shafts. Footings shall be designed to keep the soil pressure as nearly uniform as practicable. Foundation stability and settlement analyses for design shall be conducted using soil and rock properties based on the results of field and/or laboratory testing. 174 LIMIT STATES, LOAD FACTORS AND RESISTANCE FACTORS ....175 xxi xxii CONTENTS Serviceability Limit States ....175 . 339 Scope .... 184 Materials .... E Section 4 FOUNDATIONS 4.4.2 NOTATIONS fi = unit ultimate compressive strength of concrete as determined by cylinder tests at age of 28 days, MPa (Article 4.5.20.2) 719 720 HIGHWAY BRIDGES APP.E HIGHWAY BRIDGES APP. Finally, the P factor of 0.7 in the definition of D' for Equation (10-129a) has been extended to include Grade HPS70W and 70W steels based on research at the University of Nebraska at Lincoln. (See Equation 5.8.7.2-1.) Note that ASTM D 4884 will need to be modified to accommodategeogrid joints such as a Bodkin joint. 380 Allowable Stress .... Dragged ....539 539 Broomed .... Combined dead, live, and impact stresses shall not be greater than 150% of the allowable stresses. C10.34.3 Thickness of Web Plates C10.34.3.2 Girders Stiffened Longitudinally A longitudinally stiffened web must be investigated for the stress conditions at different limit states, as well as along the girder. 257 PART B-DESIGN DETAILS REPETITIVE LOADING AND TOUGHNESS . The total axial load on the shaft (Q) is equal to the sum of the mobilized side resistance (Qs) and mobilized tip resistance (Q,). 556 Vents and Drains ....556 Placement of Prestressing Steel ....556 Placement for Pretensioning ....556 Placement for Post-Tensioning ....557 Protection of Steel After Installation . 377 Values of the Bearing Area Factor, Cb,for Small BearingAreas . See also C18.4.3.1.2 (1997). 599 Arch Ring Stones .... provided product specific data is not available Temporary applications not having severe consequences should poor performanceor failure occur. For anchored walls, deflections shall be estimated in accordance with Article 5.7.2. For MSE walls, deflections may be estimated in accordance with Article 5.8.10. 71 Settlement ....71 Group Pile Loading .... 4.4.7.1.I. 1 Eccentric Loading For loads eccentric relative to the centroid of the footing, reduced footing dimensions (B' and L') shall be used to determine bearing capacity factors and modifiers (i.e., slope, footing shape, and load inclination factors), and to The effective footing area shall be determined as follows: Refer to Figure 4.4.7.1.1.1Afor loading definitions and footing dimensions. Flexure .... .24 SECTION AFOUNDATIONS Design Terminology for Spread Footing Foundations ....48 Figure 4.4.3A Figure 4.4.7.1.1.1A Definition Sketch for Loading and Dimensions for Footings Subjected to Eccentric or Inclined Loads, Modiied after EPRI (1983) ....52 Figure 4.4.7.1.1.1B Contact Pressure for Footing Loaded Eccentrically About One Axis .... 401 Attachment of Low-Friction Material . 520 Tie-rods . The reduced footing dimensions shall be determined as follows: 4.4.7.1.1 Factors Affecting Bearing Capacity A modified form of the general bearing capacity equation may be used to account for the effects of footing shape, ground surface slope, base inclination, and inclined loading as follows: Reduced footing dimensions shall be used to account for the effects of eccentric loading. Solvent Cleaning .... N-mm (Article 10.50.1.2.2) = bolt diameter, mm (Table 10.32.3B) = diameter of stud, mm (Article 10.38.5.1) = depth of beam or girder, mm (Article 10.13, Table 10.32. Such methods are based on soil and rock parameters measured directly or inferred from the results of in situ and/or laboratory tests. Spans of 50 feet and greater shall be provided with rollers, rockers, or sliding plates for expansion purposes and shall also be provided with a type of bearing employing a hinge, curved bearing plates, or pin arrangement for deflection purposes. Johnson, Ward Goodman, Charles Matlock, Joseph S. n **This shear transfer may be accomplished using mechanical fasteners, splines, or dowels along the panel joint or other suitable means. The control investigation should be performed and interpreted by experienced and qualified engineers. 305 10.38.5.1.2 Ultimatestrength . 533 Box Culverts .... z + &" B Note: &v rs as determined from Figure 5.8.12.1A, Nb= number of bolts in the joint. .450 MJMMUM SEAT-WIDTH REQUIREMENTS . Each of these situations creates a special set of conditions which should be specifically analyzed by a corrosion specialist. The following sub-articles shall supplement Articles 4.6.5.2 and 4.6.5.3.3. 107 4.13.3.2.3~ Settlement of Single Drilled Shafts The settlement of single drilled shafts shall be estimated considering short-term settlement, consolidation settlement (if constructed in cohesive soils), and axial compression of the drilled shaft. 637 Aluminum Railing .... 490 Storage and Handling .... "A Distribution Procedure forthe Analvsis of Slabs Continuous Over'Flexible Beams," by Nathan M. Pilespacing ....75 75 Minimum Projection into Cap .... 334 Composite Sections ....334 Slip-Critical Joints .... Minimum Transverse Reinforcement Requirements for Seismic Performance Category B .... VERTIUL STEM us WIWS 1 - ON 0 6 s oc G~EOw r L s ms~stwaTO OVEnrmtm SW r*MNTS LBOUT TOE* 1 SECTIO~ n-n #SISlw(Q TO SLlOlwO UORllt€O COCESIVE SOIL I*'.811 F *la a * Cp G w u m SOIL OR DIUI)(EO C W S t K SOIL IC a* / F .IW RaUI P,)ucr) Cp F *lW f)ucr b a* C, I) .hm# .2r01(F F%* TmLo5 *1 wl Y P Pn . Since singly symmetric sections are encompassed,the maximum bending strength (expressed in terms of moment capacity) must be taken as the lesser of the moment capacities computed based on the stresses in the tension and compression flanges; new Equations (10-98) and (10-99) respectively. 1.6 RAILROAD OVERPASSES 1.6.1 Clearances Structures designed to overpass a railroad shall be in accordance with standards established and used by the affected railroad in its normal practice. 1968, Rentice-Hall, Inc., Englewood Cliffs. 179 SECTION &CULVERTS CULVERT LOCATION. 197 Shear .... The tension due to the prying action shall be 10.32.3.2.3 = 105 ksi for M 164 (A 325) bolts over 1-inch diameter; = 150 ksi for M 253 (A 490) bolts. Acceptable Special Features .... 504 Bell Footings .... Sufficient research has not yet been conducted on composite sections of variable-depth members with or without longitudinal web stiffeners, composite sections of constantdepth members with longitudinal web stiffeners or on composite sections of variable- or constant-depth members with holes in the tension flange to determine if these sections can achieve the full plastic moment capacity in positive bending. 10.7.3 The radius of gyration and the effective area for canying stress of a member containing perforated cover plates shall be computed for a transverse section through the maximum width of perforation. 4.11.6.2 Excavation Monitoring Prior to concreting footings or placing backfill, an excavation shall be free of debris and excessive water. 10.16.10.4 The angle between the lacing bars and the axis of the member shall be approximately 45" for double lacing and 60" for single lacing. The Load Fraction, S/D, need not be greater than 1. Seismic Design . The word tensile is added to the definition of the bending stress, F,, for use in Equation (10-30) to agree with the definition of the same term in this same equation given in the AISC ASD Specifications. University of ~llinois,~ulletin No. 363, "Solutions,for Certain Rectangular Slabs Continuous over Flexible Supports," by Vernon P. 655 Protection of Adjacent Work . 248 POST-TENSIONINGANCHORAGES AND COUPLERS ....248 EMBEDMENT OF PRESTRESSED STRAND ....249 BEARINGS .... Therefore, as a general guide, drilled shafts in a group may be considered to act individually when the center-to-center (CTC) spacing is greater than 2.5B in the direction normal to loading, and CTC > 8B in the direction parallel to loading. 107 Analytic Estimates of Drilled Shaft Capacity 4.13.3.3.2 in Cohesive Soils .... distance from centroid of gross section, neglecting the reinforcement, to centroid of tension reinforcement, mm nominal diameter of bar or wire, mm. Also, the words 'at D15' at the end of this requirement are considered superlluous and are removed since the longitudinal stiffener does not necessarily have to be located at Dl5. 10.32.5.4.2 The allowable unit-bearing stress in pounds per square inch on bronze castings or copper-alloy plates shall be 2,000. 521 Member Placement .... C10.32 ALLOWABLE STRESSES C-119 buckling modes are given in the AISC Manual of Steel Construction, Ninth Edition, 1989. See the related provisions of Article 10.34.6. 10.34.2.1 Welded Girders 10.34.2.1.1 Each flange may comprise a series of plates joined end to end by full penetration butt welds. lA, Articles 10.48.2, 10.48.4.1 and 10.50.1.1.2) = diameter of rocker or roller, mm (Article 10.32.4.2) = beam depth, mm (Article 10.56.3) = column depth, mm (Article 10.56.3) = spacing of intermediate stiffener, mm (Articles 10.34.4, and 10.34.5, 10.48.5.3, 10.48.6.3, and 10.48.8) = modulus of elasticity of steel, MPa (Table 10.32.1A and Articles 10.15.3, 10.36, 10.37, 10.39.4.4.2, 10.54.1, and 10.55.1) = modulus of elasticity of concrete, MPa (Article 10.38.5.1.2) F F Fa Fb Fc~ Fa Fba Fb~ FD F, F: 9 FS Fsr FY' F.S. Fu Fu Fv Fv Fw APP. 491 491 Drop Hammers .... Language is added in this article to indicate that if the lateral bracing requirement given by Equation (10-101) is not satisfied, the maximum compression-flange capacity calculated from Equation (10-99) cannot exceed the lateral-torsional buckling capacity Mu determined by the provisions of Article 10.48.4.1 for partially braced members. .219 DEVELOPMENT OF SHEAR REINFORCEMENT ....220 DEVELOPMENT OF BUNDLED BARS ....220 DEVELOPMENT OF STANDARD HOOKS IN TENSION ....220 DEVELOPMENT OF WELDED WIRE FABRIC I N TENSION . Therefore, language is added at the end of this article to indicate that singly symmetric sections are subject to the requirements of Article 10.49.3. As for transversely stiffened girders without longitudinal stiffeners, the yield stress F, in the denominator of Equation (10-109) is not replaced with the factored bending stress in the compression flange fb,because the current slenderness limit (based on F,) defines a somewhat arbitrary upper bound below which fatigue due to excessive lateral web deflections is not considered to be a concern. 4.12.3.2.2 Tolerable Movement Tolerable axial and lateral movements for driven pile foundations shall be developed consistent with the function and type of structure, fixity of bearings, anticipated service life and consequences of unacceptable displacements on performance of the structure. 19 DEADLOAD .... 38 - HIGHWAY BRIDGES - - - - 3.25 DISTRIBUTION OF WHEEL LOADS ON TIMBER FLOORING 3.25 ---- - - - - support. Although the study was limited to doubly symmetric girders, the recommended minimum flange proportions are deemed to be adequate for reasonably proportioned singly symmetric I-girders. 179 Reinforcement .... Connor ALASKA, Richard A. use *Be in l i e u of 'Lm). In determining the feasibility of employing anchors at a particular location, consideration shall be given to the availability or ability to obtain underground easements, proximity of buried facilities to anchor locations, and the suitability of subsurface soil and rock conditions within the anchor stressing zone. 504 504 DRILLED SHAFT LOAD TESTS .... 573 573 Threads for Bolts and Pins .... 492 Leads .... 415 Intermediate Trench Widths .... 267 HEAT-CURVED ROLLED BEAMS AND WELDED PLATE GIRDERS .... M, and H, may be computed as follows: t D~ M ~ = 12 - IRKu- Rcufncu I 10.18.2.3.2 As a minimum, in the case of the strength design method, web splice plates and their connections shall be proportioned for a design shear in the web at the point of splice, V, defined as follows: For V < 0.5Vu: For V 2 0.5Vu: where: V = maximum shear in the web at the point of splice due to the factored loads Vu= shear capacity of the web at the point of splice *For an alternative approach for compact steel sections, reference is made to Firas I. Freedman MASSACHUSETI'S, Alexander K. FACTOR OF SAFETY - X F s AGAINST SLIDING: Horizonto1 Resisting Force(.) = ~ ~ H o r i r o n t a ~Driving Force(s) += F r i c t i o n = (VI +Vz +F. l o a d applred t o r e i n f o r c e m e n t (l o a d / u n ~ twall width). 'Gusset plates attached to girder flange surfaces with only transverse fillet welds are prohibited. F* and a shall be determined fiom product specific pullout tests in the project backfill material or equivalent soil, or they can be estimated empiricallyltheoretically.Pullout testing and interpretation procedures (and direct shear testing for some parameters), as well as typical empirical data, are provided in Appendix A of FHWA Publication No. FHWA SA-96-071"Mechanically StabilizedEarth Walls and Rein- forced Soil Slopes Design and Construction Guidelines." For standard backfill materials (see Article 7.3.6.3 in Division IQ,with the exception of uniform sands (i.e., coefficient of uniformity C, < 4), it is acceptable to use conservative default values for F* and a as shown in Figure 5.8.5.2Aand Table 5.8.5.2A. 140 External Stability for Wall with Sloping Backslope ...... .637 .. 346 STRUCTURAL PLATE PIPE STRUCTURES ....347 General .... Where soft soils are present or if on sloping ground, the difference in bearing stress calculated for the wall reinforced soil zone relative to the local bearing stress beneath the facing elements shall be considered when evaluating bearing capacity. .129 Overall Stability ....129 NONGRAVITY CANTILEVERED WALL DESIGN ....129 Design Terminology ....129 Earth Pressure and Surcharge Loadings ....129 Water Pressure and Drainage .... 251 Notations .... .I69 Structural Connection of Soil Reinforcement Around Backfill Obstructions ....,170 Lateral Earth Pressures for Prefabricated Modular Walls, Case I-Continuous Pressure Surfaces ....I72 Lateral Earth Pressures for Prefabricated Modular Walls, Case 11-Irregular Pressure Surfaces ....I73 Earth Loads and Stability Criteria for Walls with Clayey Soils in the Backfill or Foundation (after Duncan et al., 1990) ....,177 Earth Loads and Stability Criteria for Walls with Granular Backfills and Foundations on Sand or Gravel (after Duncan et al., 1990) ....I78 Earth Loads and Stability Criteria for Walls with Granular Backfills and Foundations on Rock (after Duncan et al., 1990) ....I78 Contact Pressure Distribution for Structural Design of Footings on Soil and Rock at Strength Limit States . 574 Temperature .... Fit of Stiffeners .... The influence line for moment shows that for the load in these positions, positive moments are produced over significant portions of the girder length. Pins shall be secured in position by appropriate nuts with washers. Also, a provision is added that the factored bending stress in the longitudinal stiffener is not to exceed the yield strength of the longitudinal stiffener, which parallels a similar requirement given in ASD Article 10.34.5.3. A definition has been added to clanfy that the moment of inertia of the longitudinal stiffener'is to be taken about the edge of the stiffener in contact with the web plate. MSE walls have been successfully used in both fill and cut wall applications. 423 16.5.3.2 Minimum Cover . load of the rail. 505 Test Bells .... .451 SECTION &ANALYSIS REQUIREMENTS Table 4.2A Table 4.2B Minimum Analysis Requirements .... Consideration shall be given to the use of either a geotextile or graded granular filter layer to reduce susceptibility to piping in rip rap or abutment backfill. 531 Protection During Cure .... 8 uy;LE OF FRICTION & TIYEEN WLL UO SOIL MCKflLL* 8 €OW TO ZERO FROM MSMTO T l a E 5.5.28. For cases in which the loading is eccentric, the terms L and B shall be replaced by L' and B', respectively, in the above equations. 2.4.1 Width The pier columns or walls for grade separation structures shall generally be located a minimum of 30 feet from the edges of the through-traffic lanes. 620 18.4.8.2 Adhesive .... 328 General .... 5.7.2 Earth Pressure and Surcharge Loadings The development of lateral earth pressures for design shall consider the method and sequence of construction, the rigidity of the walVanchor system, the physical characteristics and stability of the ground mass to be sup- ANCHOR HEAD ANCHOR INCLINATION AS REQUIRED PRIMARY GROUT FIGURE 5.7.1A w i c a l Terms Used in Flexible Anchored WaU Design 134 HIGHWAY BRIDGES SO1L TYPE APPARENT EARTH PRESSURE DISTRIBUTION 5.7.2 NOTATION - H FINAL WALL HEIGHT Ka- ACTIVE EARTH PRESSURE COEFFICIENT 7'- EFFECTIVE SOIL UNIT WEIGHT SAND (4) (OR PERMANENT WALLS IN CLAY) - y TOTAL SOIL UNIT WEIGHT m REDUCTION FACTOR q, UNCONFINED COMPRESSIVE STRENGTH - -IE- 0.25 H SOFT TO (4) MEDIUM CLAY (q, KaYH m 8 0 . 5.6.7 Overall Stability Continuous (soil arching) Refer to Article 5.2.2.3. Equation 5.6.6-1 is applicable for simply supported facing behind which the soil will not arch between vertical supports (e.g., in soft cohesive soils or for rigid concrete facing placed tightly against the in-place soil). The current specifications do not provide a clear criteria for determining whether or not a given block has adequate freeze-thaw resistance. 679 Latex Emulsion . 4-Allowable bearing pressure to be determined by appropriate city official. 424 16.5.3.5 Footing Design . T or Rev 16 B C D E E 16 Detail base metal attached by full penetration groove welds with a transition radius, R, regardless of the detail length and with weld soundness transverse to the direction of stress established by nondestructive inspection: -With equal plate thickness and reinforcement removed (a) Transition radius 2 24 in. 427 Design .... 169 Hydrostatic Pressures .... 4.13.3.3.8~ Group in Strong Soil Overlying Weaker Compressible Soil The provisions of Article 4.12.3.3.10~shall apply as applicable. EMBEDMENT I N ROCK NOTE: REFER TO TABLE 5 . 194 DIAPHRAGMS .... Vertical stress for maximum reinforcement load calculations shall be determined as shown in Figures 5.8.4.1Aand 5.8.4.1B. 604 Weather Conditions . 304 10.38.4 Stresses . a for determination of I,and Kp 1. 26 Railing Loading .... 74 Buoyancy ....74 Protection Against Deterioration ....74 Steel Piles . .673 . 105 4.13.3 Geotechnical Design .... Concrete Piles . 77 4.5.20.4 Hollow Cylinder Piles . 639 Waterproofing .... 541 Class 1-Ordinary Surface Finish .... 293 CastIron .... Shear connections subjected to stress reversal, or where slippage would be undesirable, shall be slip-critical connections. Note that for walls which face the sun, it is possible that the temperature irnmediately behind the facing could be higher than the air temperature. For members without holes, yielding on the gross section is checked (for Grade 1001100Wsteels, gross section yielding is conservatively checked against 0.46Fu, which is less than 0.55Fy).For members with holes, both yielding on the gross section and fracture on the net section must be checked. The positive drainage system shall be located at the lowest elevation that will permit gravity drainage. 2.7.2.1.2 Railing components shall be designed with consideration to safety, appearance, and when the bridge carries mixed traffic freedom of view from passing vehicles. 527 Cement Content .... The use of these requirements (which have the yield stress Fy in the denominator) is too conservativefor the constructibilityload case since compression stresses in the web are typically below F, during construction. Hurst, Loren R. Base metal adjacent to details attached by full or partial T or Rev penetration groove welds when the detail length, L, in the direction of stress, is between 2 in. 582 11.5.6.4.8 Lock-Pin and Collar Fasteners ....582 11.5.6.4.9 Inspection .... 68 Dowel Size .... Stone Riprap and Filter Blanket . 4.13.3.3 Resistance at Strength Limit States The strength limit states that must be considered include: (1) bearing capacity of drilled shafts, (2) uplift capacity of drilled shafts, and (3) punching of drilled shafts bearing in strong soil into a weaker layer below. .539 .. 597 lxii CONTENTS Rubble Stone .... Potential differences between the environment at the face relative to the environment within the rein- forced soil mass shall be considered when assessing potential corrosion losses. Hydraulic Studies .... Load and Resistance Factor Design, LRFD Specification for Structural Steel Buildings and Comrnentary, AISC, 1" Edition, September 1,1986. .... -534 Underwater Placement .... 481 Salvage ....481 Partial Removal of Structures . Cross frames shall be as deep as practicable. 335 DEFLECTION .... 10.24 FASTENERS (RIVETS AND BOLTS) 10.24.1.5 High-strength bolted connections subject to computed tension or combined shear and computed tension shall be slip-critical connections. The attachment shall also be designed to resist an inward transverse load equal to onefourth the transverse rail design load. S WYI SI1IEILiT)l OF FOUKYTION m AT ZERO W R M U L W . The base slabs of counterforted and buttressed walls shall be designed as fixed or continuous beams of spans equal to the distance between counterforts or buttresses. A., M. 2.3.2 Vertical Clearance The provisions of Article 2.2.3 shall be used. 573 Curved Girders .... Shapes All Groups All Groups Axial tension in members with no 0.55Fy holes 0.46Fu Axial tension in members with holes Gross and tension in extreme fiber of Section rolled shapes, girders, and built-up 0.55Fy sections with holes subject to bending. C10.50.2.2 Noncompact Sections This article is revised to correspond with the above revisions to Article 10.48.2 for braced noncompact sections, except that the maximum strength is specified separately for the tension and compression flange and is expressed in terms of stress rather than moment for reasons discussed previously. M, in a 1-foot height of wall facing at any level may be determined by the following, or other acceptable design procedures: 5.6.5 Structure Dimensions and External Stability Simple span (no soil arching) Simple span (soil arching) M,, = pat2/12 5.6.6 DIVISION I-DESIGN Continuous (no soil arching) 133 sidered adequate with respect to the decay hazard and expected service life of the structure. 391 PTFE Surface .... 493 Excavation .... .265 Nominal Hole Dimension .... Microbiological attack may also affect certain polymers, though in general most of polymers used for carrying load in soil reinforcement applications are not affected by this. (2) Surcharge and water pressures must be added to the indicated earth pressures. 104 Group Capacity ....104 Cohesive Soil .... 287 ALLOWABLE STRESSES . For the static component, For the dynamic component, Tmd S, x RC FSxmxRF,, (5.8.9.2-4) Therefore, the ultimate strength of the geosynthetic reinforcement required is, Tult = S, + S* (5.8.9.2-5) For reinforcement pullout, FSPO x Tm, L > e-0.8F* x x x xo,x C x Rc (5.8.9.2-6) For the dynamic component, T md 0.8 in. 3.24.6.3 The distribution width, E, for the load taken by either span shall be determined as provided for other slabs. COMMENTARY TO SECTION 1843OIL-THERMOPLASTIC PIPE INTERACTION SYSTEMS This change is recommended as a result of work done under NCHRP Project 4-24 as reported in NCHRP Report 429 to address environmental stress cracking in AASHTO M 294 polyethylene culverts. calculate the ultimate load capacity of the footing. 489 Steel Piles ....489 .. 341 Handling and Installation Strength .... .490 Working Drawings

(*+ 9-9011 wth 8. The magnitudeof rotation required to develop active pressure is a function of the soil type and conditions behind the wall; as defined in Table 55.2A. Stretchers ... tsn (V- - - 0) f w n ~ - 6j[tan(- B)+ cot(*+ 1 q0)][1 + tsn (b+ 90 8)cot l*+ 1-9011 1 + +M 1b+ 90 - 1 l t u n (*-a)+ cot (*+ 9-9011 wth 8. The design of longitudinal and spiral reinforcement shall be in conformance with the requirements of Articles 8.18.1 and 8.18.2.2, respectively. Displacement analyses should be conducted to determine the relationship between estimated settlement and footing size to optimize footing size with respect to supported loads. 599 Selection and Placing of Stone ... 599 599 General ... 2.6.3 Curbs The width of curbs shall be not less than 18 inches. T or Rev E - Shear stress on throat of fillet welds. For sliding stability, the coefficient of sliding used to calculate frictional resistance at the base of the wall shall be the minimum of the following determinations: Tan 4 at the base of the wall, where 4 is the friction angle of the backfill or the foundation soil, whichever is lowest. Nickas GEORGIA, Paul Liles, Brian Swinners HAWAII, Paul Santo IDAHO, Matthew N. ... 455 Mathematical Model ... 478 OtherFoundations .415 Earth Load Bedding Factor for Arch and Elliptical Pipe . 61 4.4.8.1 Bearing Capacity ... AshlarMasonry . 505 Permanent Casing ... 525 525 Normal Weight Concrete ... When the original ASD code was developed, the constructibility check for dead load alone was not explicitly considered. The performance factors for the group capacity calculated using the sum of the individual pile capacities, are the same as those for the single pile capacity as given in Table 4.10.6-2. Extensible reinforcements reach their peak strength at strains greater than the strain required for soil to reach its peak strength. and S. It is therefore recommended that if the anticipated ground acceleration is greater than 0.29 g, a detailed lateral deformation analysis of the structure during seismic loading should be performed. 117 Minimum Coverage ... Camp NEW YORK, James O'Connell, George Christian NORTH CAROLINA, Gregory R. Footings are considered to be adequate against soil failure if the factored bearing capacity exceeds the effect of design loads. The rock mass modulus (E d should be determined based on the results of in-situ testing (e.g., pressure-meter) or estimated from the results of laboratory tests in which Emis the modulus of intact rock specimens, and (E,) is estimated in accordance with Article 4.4.8.2.2. For preliminary design or when site-specific test data cannot be obtained, guidelines for estimating values of E,, such as presented in Table 4.4.8.2.2B or Figure 4.4.8.2.2A, may be used. C10.53 HYBRID GIRDERS This article states that for hybrid girders, Fy is to be taken as the specified minimum yield strength of the different under consideration with the exceptions listed. 1.2 BRIDGE LOCATIONS The general location of a bridge is governed by the route of the highway it carries, which, in the case of a new highway, could be one of several routes under consideration. For ultimate limit state conditions for per- manent walls, a FS of 1.5 shall be used. 2 X in. in dia. 211 Hooked-Bar Details for Development of Standard Hooks . 461 Special Pile Requirements ... 423 16.5.2.1 Concrete ... An upper limit of 24 is also specified on the b/t ratio of tension flanges for reasons discussed previously. 303 Flangeplates . P 't the r o l l f For discontinuous soil reinforcements (e.g.. 233 Prestress Losses ... 526 Lightweight Aggregate ... 192 REINFORCEMENT ... 217 ... (See Article 10.40.3 for Hybrid Girders.) 10.34.2.2.5 The gross area of the compression flange, except for composite design, shall be not less than the gross area of the tension flange. The gage between adjacent lines of fasteners shall not exceed 24t; t = the thickness, in inches, of the thinner outside plate or shape. SOI Casings ... Compression-flange widths are preferably not to be less than 0.2 times the web depth, but in no case less than 0.15 times the web depth. 360 Tabulated Values for Structural Composite under + 5.8.3 Bearing Capacity and Foundation Stability Allowable bearing capacities for MSE walls shall be computed using a minimum factor of safety of 2.5 for Group 1 loading applied to the calculated ultimate bearing capacity. 397 Shear ... Placement of Anchorage Hardware ... 557 IDENTIFICATIONAND TESTING ... 557 Pretensioning Method Tendons . 199912000 COMMENTARY The hybrid factor R is eliminated because web yielding, should it occur, is limited or overload. 4.4.8 Geotechnical Design on Rock Spread footings supported on rock shall be designed to support the design loads with adequate bearing and structural capacity and with tolerable settlements in conformance with Articles 4.4.8 and 4.4.11. The compression-flange capacity is also modified by the flange-stress reduction factor Rbin Equation (10-99). 624 SECTION 2LMETAL CULVERTS Table 26.4 Table 26.6 Categories of Pipe Joints ... 661 Minimum Cover for Construction Loads (Round, Pipe.Arch, C 22 SECTION 1 5 T C E E L TUNNEL LINER PLATES Figure 15.2.3A Diagram for Coefficient Cdfor Tunnels in Soil (S = Friction Angle) . Note that it is possible use of default reduction factors may be acceptable where the reinforcement load is maximum (i.e., in the middle of the wall backfill) and still not be acceptable at the facing connection if the facing connection is defined as aggressive. -592 Stream Clearing . T. Where stress levels are high, consideration should be given to methods of load transfer analysis. 284 HIGHWAY BRIDGES The maximum slenderness ratio, the requirements for fasteners in built-up members shall be governed by the requirements for sealing or stitch fasteners, whichever is the minimum. by a geotechnical engineer. 336 Steel Conduits ... 346 Aluminum Conduits ... 346 Chemical and Mechanical Requirements . As a result, the upper limit on web slenderness in the statement immediately above Equation (101030)is redundant and need not be specified. The load in the reinforcement is determined at two critical locations, i.e., at the zone of maximum stress and at the connection with the wall face, to assess the internal stability of the wall system. Siebels, David Pope, and Tom Lulay. See Figure 5.5.2B to estimate the effects of permanent point and line surcharge loads. 198 Shear Stress Carried by Concrete . 462 REINFORCED CONCRETE DESIGN REQUIREMENTS FOR SEISMIC PERFORMANCE CATEGORY B ... 462 462 General ... SECTION 1 A T O N E MASONRY 14.1 14.1.1 14.1.2 14.2 DESCRIPTION ... 688 LIST OF TABLES DIVISION I DESIGN SECTION &LOADS Table 3.22.1A Table 3.23.1 Table 3.23.3.1 SECTION "'01 Table 4.2.3A Table 4.4.7.1A Table 4.4.7.2.2A Table 4.4.7.2.2B Table 4.4.8.1.2A Table 4.4.8.1.2B Table 4.4.8.2.2A Table 4.4.8.2.2B Table 4.5.6.2A Table 4.5.7.3A Table 4.6.5.1.1A Table 4.6.5.1.4A Table 4.10.6-1 Table 4.10.6-2 Table 4.10.6-3 Table 4.11.4.1-1 Table 4.11.4.2.4-1 Table of Coefficients y and P ... 31 Distribution of Wheel Loads in Longitudinal Beams ... 294 10.34.1 General ... The expansion end shall be secured against lateral movement. 322 General ... 322 Singly Symmetric Sections with Transverse Stiffeners ... 322 Longitudinally Stiffened Singly Symmetric Sections ... 322 Singly Symmetric Braced Noncompact Sections ... 323 Partially Braced Members with Singly Symmetric Sections ... 4.3.3.2.3 Settlement The settlement of a drilled shaft foundation involving either single drilled shafts or groups of drilled shafts shall not exceed the tolerable settlement as selected according to Article 4.13.3.2.2 (4.13.3.3.4 Axial Capacity in Rock) In determining the axial capacity of drilled shafts with rock sockets, the side resistance from overlying soil deposits shall be ignored ... 534 Equipment ... 10.32.4.2 Design stresses for Steel Bars, Carbon Cold Finished Structural Quality, AASHTO M 169 (ASTM A 108); and Steel Forgings, Carbon and Alloy, for General Industrial Use, AASHTO M 102 (ASTM A 668), are given in Table 10-32.4.3A. 601 Stone ... 4.11.1.5 Anchorage Footings which are founded on inclined smooth solid rock surfaces and which are not restrained by an overburden of resistant material shall be effectively anchored by 34 HIGHWAY BRIDGES 4.11.5 TABLE 4.10.6-1 Performance Factors for Strength Limit States for Shallow Foundations Performance Factor ('Ope of Limit State 1. ("'-S'P? corrected for depth. The minimum fillet weld size shall be as shown in the following table. Similar language was formerly located at the end of Article 10.48.4.1. C10.49.3 Longitudinally Stiffened Singly Symmetric Sections The word 'unsymmetrical' is replaced with the words 'singly symmetric' in the heading to this article. (See Table 10.32.3B, footnote h). 383 Washers ... See Figure 5.8.6A for an illustration of how to calculate the long-term strength of the reinforcement based on these parameters. .701 INDEX ... In the selection of the waterway opening, consideration should be given to the amount of upstream ponding, the passage of ice and debris and possible scour of the bridge foundations. In built-up pedestals and shoes, the web plates and angles connecting them to the base plate shall be not less than ½ inch thick. If brush curbs or curbs are not used, the clear width shall be the minimum width measured between the nearest faces of the bridge railing. 315 10.41.4.8.1 Deflections ... 315 +brations ... 650 Payment ... 650 General ... 650 Stone Riprap ... 266 CAMBER ... 559 Water ... The nominal diameter of the bolt shall be used in calculating the bolt stress. The applied load shall be the sum of the external load and any tension resulting from prying action. 10.23 WELDING 10.23.1 General 10.23.1.1 Steel base to be welded, weld metal, and welding design details shall conform to the requirements of the ANSVAASHTO/AWS D1.5 Bridge Welding Code. (3) Along edges of material V4 inch or more in thickness, the maximum size shall be %6 inch less than the thickness of the material, unless the weld is especially designated on the drawings to be built out to obtain full throat thickness. Also, the reference to open holes larger than 0/4 inches is removed because fracture is to now to be checked on the net section in all cases for members with holes, regardless of the hole size. They shall be secured by cotter pins in the screw ends or else the screw ends shall be long enough to permit burring the threads. 8 FIGURE 5.8.2A External Stability for Wall with Horizontal Backslope and surfac Surcharge DIVISION I-DESIGN 5.8.2 (4) Supporting ... 110 10.4 SPICING 24 CE Lo 15 ... Fol -I FACTOR OF SAFETY AGAINST OVERTURNING (MOMENTS ABOUT POINT 0) : V,' (L/2) + VI(2L/3) + F, (L) X Moments Resisting (Mr) FSo, = e 2.0 Z Moments Overturning (Mo) FH (h/3) . 554 Post-Tensioning Anchorages and Couplers ... Part C SERVICE LOAD DESIGN METHOD ALLOWABLE STRESS DESIGN 10.31 SCOPE Allowable stresses in design, such as are specified herein, serve as a method for proportioning structural members using design loads and forces, allowable stresses, and design limitations for the appropriate material under service conditions. 661 Joint Types ... ... lb = 20 70,000 psi, Y,P Min. - U,0n - Mols: (1) S I E C W G E M H A T E R P ~ T I-S T B E A D E D F O T D A M (N e emm PRESSURES. Design of Facing Elements . 410 Standard Trench Installation Soils and Minimum Compaction Requirements . The advent of composite design has led to a significantforeduction in the size of compression flanges in positive moment regions. Local experience should be applied when establishing project design values based on laboratory and field tests. Existing Decks ... 680 Proportioning and Mixing ... 681 Installation ... Freemon NEVADA, William C. 3.24.4 Shear and Bond Slabs designed for bending moment in accordance with Article 3.24.3 shall be considered satisfactory in bond and shear. 10.21.2 A horizontal wind force of 50 pounds per square foot shall be applied to the area of the superstructure exposed in elevation. 2.7.2.2.2 Within a band bordered by the bikeway surface and a line 27 inches above it, all elements of the railing assembly shall be spaced such that a 6-inch sphere will not pass through any opening. C10.38.4 Stresses This article specifies the ASD requirement for minimum longitudinal reinforcement in the concrete deck. 63 4.4.8.2.1 Footings on Competent Rock ... C10.34.2.2 Riveted or Bolted Girders The width-to-thickness requirement for unsupported outstanding legs of top flange angles in compression in composite girders under the noncomposite dead load [Equation (10-22)] is revised to be consistent with the revision made to Equation (10-20 of Article 10.34.2.1.5, as described below. 505 Exploration Holes ... 296 10.34.3.1 10.34.3.2 Girders Stiffened Longitudinally ... 10.24.7.2 When there is only a single transverse fastener in the direction of the line of force in a standard or short slotted hole, the distance from the center of the hole to the edge of the connected part shall not be less than 1½ times the diameter of the fastener, unless accounted for by the bearing provisions of Table 10.32.3B or Article 10.56.1.3.2. 10.24.7.3 When oversize or slotted holes are used, the clear distance between edges of adjacent holes shall not be less than the diameter of the bolt. .423 i6.5.2 Materials ... 449 Precast Slope Paving ... 649 MEASUREMENT AND PAYMENT ... 649 Method of Measurement ... 285 FIXED AND EXPANSION BEARINGS ... 400 General ... 526 Air-Entraining and Chemical Admixtures . 231 Basic Assumptions ... The RQD used in Figure 4.4.8.1.1A shall be the average RQD for the rock within a depth of B below the base of the footing, where the RQD values are relatively uniform within that interval. Changes in flange areas may be accomplished by varying the thickness and/or width of the flange plate, or by adding cover plates. 108 HIGHWAY'BRIDGES If the rock is degradable, consideration of special construction procedures, larger socket dimensions, or reduced socket capacities shall be considered. Fredrick, Keith B. 639 Primer ... For preliminary analyses or for final design when in-situ test results are not available, a value of a= 0.15 should be used to estimate Ein. 4.6.5.5.3 Tolerable Movement Refer to Figure 4.6.5.5.2A to determine I,. Embankment slopes adjacent to structures subject to erosion should be adequately pro- 4 HIGHWAY BRIDGES tected by rip-rap, flexible mattresses, retards, spur dikes or other appropriate construction. 4.4.7.1.1.1 Eccentric Loading of Footings In proportioning footings, the effect of eccentric loading shall be considered. ... 12 ... 0.5 ... 0.8 ... 1.0 ... 2.5 ... 5.0 ... 10 ... Footing with one-way ... of bolts p = Hwu/Nb where: m = number of vertical rows of bolts n = number of bolts in one vertical row e = the vertical pitch p = the horizontal pitch 1999/2000COMMENTARY SPLICE-DESIGN REQUIREMENTS Use Mvu,Mwuand Hwuto check: 1) flexural yielding on the gross section of the web splice plates Use Vwuto check: 1) shear yielding on the gross section of the web splice plates C-117 HIGHWAY BRIDGES C-118 SPLICE-DESIGN REQUIREMENTS Check slip resistance of the web bolts in a similar fashion by: 1) Replacing V, with Vow. 294 10.33.1 General . 4.13.4 Structural Design The structural design of drilled shafts shall be in accordance with the provisions of Article 4.6.6, which was developed for allowable stress design. 500 4.13 (LRFD) DIVISION I-DESIGN duces. Table 4.10.4-1 Load Factors and Load Combinations 4.10.4 DIVISION I-DESIGN 4.10.3.1 Concrete Deck Panels When precast prestressed deck panels are used as permanent forms spanning between beams, stringers, or girders, the requirements of Article 9.12, Deck Panels, and Article 9.23, Deck Panels, shall be met. 450 Elastic Seismic Response Coefficient for Mdtimodal Analysis ... 450 RESPONSE MODIFICATION FACTORS ... 450 DETERMINATION OF ELASTIC FORCES AND DISPLACEMENTS . 578 578 11.5.6.4.1 Installation ... 651 (c) Available bulb water marks with dates of occurrence. Design Force for Flange Splice Plates ... Where filler plates are required, the requirements of Article 10.18.1.2.1 shall also be satisfied. 278 ... 566 Structural Steel ... 68 Application ... The procedure for determining the resultant passive resistance of a vertical element embedded in soil assumes that net passive resistance is mobilized across a maximum of three times the element width or diameter (reduced, if necessary, to account for soft clay or discontinuities the embedded depth of soil or rock) and that some portion of the embedded depth below finished grade (usually 2 to 3 feet for an element in soil, and 1 foot for an element in rock) is ineffective in providing passive lateral support. 800 Sandstone and Limestone . 503 ... (b) Slabs supported on steel stringers, or slabs supported on thin top flange prestressed beams with top flange width to minimum thickness ratio equal to or greater than 4.0: "S" shall be the distance between edges of top flange plus one-half of stringer top flange width. = ¶Ihp· 90 General ... Reinforcement ... The values of the constant X given in the article reflect different assumptions of support provided to the web by the flanges to prevent local web bend-buckling. Maximum Spacing of Fasteners ... Bolted splices in flexural members shall satisfy the requirements of Article 10.18.3. Bolted splices in tension members shall satisfy the requirements of Article 10.18.4. Welded splices shall satisfy the requirements of Article 10.18.5. Where a section changes at a splice, the smaller section is to be used to satisfy the above splice requirements. ... 510 Transportand Storage ... 511 For composition flanges, the maximum strength, F, of the flange is taken equal to FyRb.The flange-stress reduction factor Rbaccounts for the increase in compression-flange stress that results due to local web bend-buckling and is to be computed according to the provisions of Article 10.48.4.1. To provide some additional relief at more lightly loaded sections, Rbis to be computed using the actual factored compression-flange bending stress fbin place of the term M,/S,, when fbis computed using Equation (10-103b) in Article 10.48.4.1. fb cannot exceed F,. 272 SPLICES ... Due to their flexibility and method of support, the distribution of lateral pressure on anchored walls is influenced by the method and sequence of wall construction and anchor prestressing. 10.29.1.3 In lieu of the above requirements, elastomeric bearings may be used. 10.41.1 Moments and Shears ... 315 HIGHWAY BRIDGES 288 10.32.2 TABLE 10.32.1A Allowable Stresses- Structural Steel (in pounds per square inch) Structural Carbon Steel 5F+3 High-Strength Low-Alloy Steel Quenched and Tempered Low-Alloy Steel High-Yield Strength Quenched and Tempered Alloy Steela AASHTO ~esignation~" M 270 Grade 36 M 270 Grade 50 M 270 M 270 M 270 Grade 50W Grade 70W Grade 100/100W Grade 70W Equivalent ASTM Designation' A 709 Grade 36 A 709 Grade 50 A 709 A 709 A 709 Grade 50W Grade 70W Grades 100/100W Grade 70W Thickness of Plates Up to 4 in. The horizontal anchor spacing and anchor capacity must be selected to provide the required total anchor force. These supports may be longitudinal or transverse, or both, as may be required to support all edges properly. 3.27.3.4 When investigating for fatigue, the minimum cycles of maximum stress shall be used. 500 TENSIONING ... 269 . 516 Pipe and Perforated Pipe ... 272 HIGHWAY BRIDGES 10.17.5 Bottom Struts The bottom struts of towers shall be strong enough to slide the movable shoes with the structure unloaded, the coefficient of friction being assumed at 0.25. 611 Framing ... Lane loads are distributed over a width of 2E. The pin plates shall be long enough to develop the pin plate beyond the bearing 'ear stay at the stay plate, but not less than the length required by Article 10.25.4. 10.29 FMED AND EXPANSION BEARINGS 10.29.1 General 10.26 UPSET ENDS Bars and rods with screw ends, where specified, shall be upset to provide a section at the root of the thread, which will exceed the net section of the body of the member by at least 15%. 600 Field Joints ... 36 Cantilever Slabs ... 10.32.3.2.1 In addition to the allowable stress requirements of Article 10.32.3.2 the force on a slip-critical connection as defined in Article 10.24.1 shall not exceed the allowable slip force (P,) of the connection according to TABLE 10.32.3C 291 10.32.3.2.2 Subject to the approval of the Engineer, coatings providing a slip coefficient less than 0.33 may be used provided the mean slip coefficient is established by test in accordance with the requirements of Article 10.32.3.2.3, and the slip resistance per unit area are established. 528 Mineral Admixtures ... 677 Meaningfulness . 4.11.4.2.3 Load Test Where appropriate, load tests may be performed to determine the bearing capacity of foundations on rock. 133 Earth Pressure and Surcharge Loadings ... Base metal and weld metal in or adjacent to full penetration T or Rev groove weld splices of rolled or welded sections having similar profiles when welds are ground flush with grinding in the direction of applied stress and weld soundness established by nondestructive inspection. 587 Working Drawings ... In general, rails should project beyond the face of piers and/or pickets. 4.11.1.9 Nearby Structures In cases where foundations are placed adjacent to existing structures, the influence of the existing structures on the behavior of the foundation and the effect of the foundation on the existing structures, shall be investigated. ONE TRAFFIC LANE where, = minimum yield point of steel pins in pounds per square inch (see Table - - 10.32.1A); n, R, Mv= as previously defined; CR,CM = steel stress coefficients as given in preceding table. 522 SECTION 6CONCRETE STRUCTURES 525 GENERAL ... 1 4.4.11.4 Grid bearing member II II I1 . Seepage forces may be determined by flow net procedures or various analytical methods. Roadwaywidth ... 7 Verticalclearance ... 7 Other ... 7 Curbs and Sidewalks . Factors of safety and methods of analysis provided in Article 5.2.2.3 are still applicable. .202 Strength Requirements . 179 Base of Footing Slabs ... 659 Fabrication ... 688 Joints . 4.4.7.2 Settlement The total settlement includes elastic, consolidation, and secondary components and may be determined using the following: + S, + S, (4.4.7.2-1) Elastic settlement shall be determined using the unfactored dead load, plus the unfactored component of live and impact loads assumed to extend to the footing level. 213 Bottom Slab Reinforcement for Box Girders ... 575 Flatness of Panels ... 575 Straightness of Longitudinal Stiffeners Subject to Calculated Compressive Stress, Including Orthotropic-Deck Ribs ... 576 Straightness of Transverse Web Stiffeners and Other Stiffeners Not Subject to Calculated Compressive Stress ... 570 Oxygen Cutting ... 570 Visual Inspection and Repair of Plate Cut Edges ... 570 Unsafe. 570 General ... Internal stability is determined by equating the tensile load applied to the reinforcement to the allowable tension for the reinforcement, the allowable tension being governed by reinforcement rupture and pullout. 658 MEASUREMENT ... 104.1 Figure C4.13.3.3.4 Bearing Capacity Coefficient, K , after Canadian GeotechnicalSociety (1985) ... 525 Related Work ... 449 SEISMIC PERFORMANCE CATEGORIES ... 453 Reliable Bridge Requirements . The Rb factor is to be applied only to the stresses in the steel flange. 179 Wall Stems ... Arches ... By controlling the crack size in regions where adequate shear connection is provided, the concrete deck can be considered to be effective in tension for serviceability checks (e.g. fatigue) as long as adequate shear connection between the deck and the girders is also provided. 105 4.13 DRILLED SHAFTS ... 158 g r ~ 6 sand sheets). Other suitable applications may be warranted on bridge-length culverts as addressed in the AASHTO Roadside Design Guide. Of course, polymer materials not meeting the requirements in Table 5.8.6.1-2 could be used if this detailed product specific data extrapolated to the design life intended for the structure is obtained. 639 Dampproofing ... 639 MATERIALS ... 639 ... In addition, the capacity of footings subjected to seismic and dynamic loads, shall be evaluated in conformance with Articles 4.4.7.3 and 4.4.10. C10.50 COMPOSITE SECTIONS C10.49 SINGLY SYMMETRIC SECTIONS The heading for this LFD article is renamed from 'UNSYMMETRIC BEAMS AND GIRDERS' to 'SINGLY SYMMETRIC SECTIONS' to more appropriately reflect the fact that the provisions under this heading refer to 'sections' that are symmetric about one the axis of the cross section. 41 .. 462 Transverse Reinforcement for Confinement ... 660 General ... C-120 HIGHWAY BRIDGES C10.32.4 Pins, Rollers, and Expansion Rockers An editorial correction is indicated in this article. 516 General ... 107 4.13.3.2.5 Lateral ... 5.7.7 Overall Stability Refer to Article 5.2.2.3. 5.7.8 Corrosion Protection Prestressed anchors and anchor heads shall be protected against corrosion consistent with the ground and ground water conditions at the site. where, I = moment of inertia; J = Saint-Venant torsion constant; p = Poisson's ratio for girders. .399 Stability ... 400 . 316 LOADS ... 406 SECTION 16SOIL-REINFORCED CONCRETE STRUCTURE INTERACTION SYSTEMS Table 16.4A Table 16.4B Table 16.4C Table 16.4D Table 16.4E Table 16.4F Standard Embankment Installation Soils and Minimum Compaction Requirements . For more reinforcement connections, safety factors for combined static and seismic loads may be reduced to 75% of the safety factors used for static loading. 10.21.7 If a double system of bracing is used, both systems may be considered effective simultaneously if the members meet the requirements both as tension and compression members. 485 General ... The required horizontal component of each anchor force shall be computed using the apparent earth pressure distributions in Figure 5.7.2A, or other applicable earth pressure distributions, and any other horizontal water pressure, surcharge or seismic forces acting on the wall. 584 11.7 MEASUREMENT AND PAYMENT ... 584 11.7.1 Method of Measurement ... 584 11.7.2 Basis of Payment ... 77 Lugs, Scabs, and Core-Stoppers ... The diameter of shafts with rock sockets should be sized a minimum of 6 inches larger than the diameter of the socket. 424 16.6.4 General Requirements . 403 Division I Division I CONTENTS ... 133 Guidelines for Estimating Earth Pressure on Walls with W o or More Levels of Anchors Constructed from the Top Down, Modified after Tenaghi and Peck (1967) ... 134 Settlement Profiles Behind Braced or Anchored Walls, Modified after Clough and O'Rourke (1990) ... Inspection ... 80 4.6.4 Selection of Soil and Rock Properties . xxxvii xxxviii CONTENTS Dimensions ... 94 Uplift . 10.24.1.2 High-strength bolts may be substituted for Grade 1 rivets (ASTM A 502) or ASTM A307 bolts. Fbn=S, is the pullout resistance P,per unit of reinforcement width. 2-Massive crystalline bedrock. Mineral Admixtures ... 62 4.4.8.1.2 Footings on Broken or Jointed Rock ... 77 Driving . ARRANGEMENT OF SECTIONS 43 Selection of Foundation Q p = ... 63 Empirical Curve for Estimating Anticipated Lateral Displacement During Construction for MSE Walls ... Due consideration should be given to any federal, state, and local requirements. 88 GroupAction ... 74 Reliable Movement ... F, = nominal slip resistance per unit of bolt area from Table 10.32.3C, ksi. Intermediate cross frames shall preferably be of the cross type or vee type. Gere. These plates shall be con- 10.25.4 DIVISION I-DESIGN 285 need be present enough rivets, bolts, or fillet and plug welds to transmit the bearing pressure, and so arranged as to distribute it uniformly over the full section. 4.11.4.2.1 99 DIVISION I-DESIGN TABLE 4.11.4.2.1-1 Presumptive Allowable Bearing Pressures for Spread Footing Foundations Modified after U.S. Department of the Navy, 1982 Allowable Bearing Pressure (tsf) Type of Bearing Material Massive crystalline igneous and metamorphic rock: graphite, diorite, basalt, gneiss, thoroughly cemented conglomerate (sound condition allows minor cracks) Foliated metamorphic rock: slate, schist (sound condition allows minor cracks) Sedimentary rock: hard cemented shales, siltstone, sandstone, limestone without cavities Weathered or broken bedrock of any kind except highly argillaceous rock (shale) Compaction shale or other highly argillaceous rock in sound condition Well-graded mixture of fine- and coarse-grained soil: glacial till, hardpan, boulder clay (GW-GC, GC, SC) Gravel, gravel-sand mixtures, boulder-gravel mixtures (SW, SP, SW, SP) Coarse to medium sand, sand with little gravel (SW, SP) Fine to medium sand, silty or clayey medium to coarse sand (SW, SM, SC) Fine sand, silty or clayey medium to fine sand (SP, SM, SC) Homogeneous inorganic clay, sandy or silty clay (CL, CH) Inorganic silt, sandy or clayey silt, varved silt-clay-fine sand (ML,MH) Ordinary Range Recommended Value for Use Very hard, sound rock 60 to 100 80 Hard sound rock 30 to 40 35 Hard sound rock 15 to 25 20 Medium hard rock 8 to 12 10 Medium hard rock 8 to 12 10 Very dense 8 to 12 10 Very dense Medium dense to dense Loose Very dense Medium dense to dense Loose Very dense Medium dense to dense Loose Very dense Medium dense to dense Loose Very stiff to hard Medium stiff to stiff Soft Very stiff to hard Medium stiff to stiff Soft 6 to 10 4 to 7 2 to 6 4 to 2 to 4 1 to 3 1 to 3 to 5 2 to 4 1 to 3 2 to 5 1 to 2 to 5 1 to 2 to 4 0.5 to 1.5 0.5 to 1.5 0 5 2 to 5 0.5 to 0 2 to 3 to 4 7 1 5 3 1 5 1.5 5 1.5 5 1 5 2.5 1.5 2 5 1.5 Consistency in Place 4 2 0.5 3 1.5 0.5 100 HIGHWAY BRIDGES 4.4.1.4.2.2 Analytic Method The ultimate bearing capacity of foundations on rock shall be determined using established rock mechanics principles based on the rock mass strength parameters. The effect of the longitudinal stiffener is not considered in determining the shear capacity of a girder that it has not been studied in enough detail to do so. I., "Design Method for BearingType Bolted Connections with Fillers," accepted for publication in a future edition of the AISC Engineering Journal. Where required, additional lateral resistance should be provided by drilling and grouting steel dowels into the rock surface rather than blasting to embed the footing below the rock surface. 452 ... Load tests shall be conducted using a test shaft(s) constructed in a manner and of dimensions and materials identical to those planned for the production shafts into the materials planned for support. C10.48.3 Transitions The word 'members' is replaced with the more appropriate word 'sections' in this article. 635 WORKING DRAWINGS . Articles 10.50.2.1 and 10.50.2.2 refer back to the appropriate provisions of Article 10.48 where necessary. See Article 4.13.3.3.3 for a discussion on the selection of performance factors for drilled shaft capacities in cohesionless soils. 3.24.6 Slabs Supported on Four Sides 3.24.6.1 For slabs supported along four edges and reinforced in both directions, the proportion of the load carried by the short span of the slab shall be given by the following equations: For uniformly distributed load, p = b4 (a4 + b4) For concentrated load at center, p = a3 + b3 where, p = proportion of load carried by short span; a = length of short span of slab; b = length of long span of slab. 193 STIFFNESS ... The horizontal inertial force P, is determined by multiplying the weight of the reinforced wall mass, WIS dimensions of H (wall height) and 0.5H, assuming horizontal backfill conditions, by the acceleration A,. 4.10.3 Strength Limit States Strength limit states for foundation design shall include: DIVISION I-DESIGN -bearing resistance failure, -excessive loss of contact, -sliding at the base of footing, -loss of overall stability, and -structural capacity. Shear in Tension Members . Materials ... 390 Geometric Requirements ... 390 Contact Stresses ... 164 Special Loading Conditions ... 5.2.2.4 Tolerable Deformations Tolerable vertical and lateral deformation criteria for retaining walls shall be developed based on the function and type of wall, unanticipated service life, and consequences of unacceptable movements (i.e., both structural and aesthetic). 29 Dynamic Ice Force ... 10.13 COVER PLATES 10.13.1 The length of any cover plate added to a rolled beam shall be not less than (2d)-3) feet, where (d) is the depth of the beam in feet. 2.7.3 Pedestrian Railing 2.7.3.1 Effective Length of Fillet Welds The minimum effective length of a fillet weld shall be four times its size and in no case less than 1½inches. Framing and Boring ... 409 Gas and Vapors ... 409 Handrail Placing Stones 647 Machine-Placed Stones . 329 Braced Noncompact Sections ... 395 Design Requirements . 8 HIGHWAY BRIDGES 2.2.5 2.2.5 Curbs and Sidewalks The face of the curb is defined as the vertical or sloping surface on the roadway side of the curb. 123, No. 10, October, 1997, pp. If Tan p is determined experimentally based on soil to reinforcement contact, Tan p shall be reduced by 30 % where reinforcement to reinforcement contact is anticipated. 478 General . Cracks do n l t occur just within the heat-affected zone of the actual weld. ØTbetensilestrength of M 164 (A 325) bolts decreases for diameters greater than 1 inch. For cases in which the loading is eccentric, the terms L and B shall be replaced by L' and B', respectively,in the above equations. 278 General ... C10.48.2 Braced Noncompact Sections Editorial revisions are indicated to clarify that the term 'braced noncompact sections' indeed refers to 'sections' and not to 'members'. .654 Placement of Mortar ... Allowable stresses on the effective areas of weld metal shall be as follows: Butt Welds: The same as the base metal joined, except in the case of joining metals of different yields when the lower yield material shall govern. 246 Bearing Strength ... If the cap is in firm contact with the ground, then no reduction in efficiency shall be required. .395 General ... 395 Material Properties ... 561 Post-Tensioning Method Requirements . For hybrid sections, Myshall be computed in accordance with Article 10.53.1.1. ... The calculated value of ultimate bearing capacity shall be multiplied by an appropriate performance factor, as given in Article 4.10.6, to determine the factored bearing capacity. -- --- 3.27.3.3 Edges of open grid steel floors shall be supported by suitable means as required. 10.8.6 For stiffeners and outstanding legs of angles, etc., refer to Article 10.10. The required bearing length is a function of the force in the compression flange being braced. 123 Organizational Procedures for Passive Earth Pressures for Sloping Wall with Horizontal Backfill (Caquot and Kerisel Analysis), M d e d after US. 394 Pot ... Monsoli MAINE, James E. 611 Sills ... 508 Bond Length and Tendon Bond length ... 508 Grout Protected Grout Anchor Tendon ... 508 . 553 Working Drawings ... 553 Division II CONTENTS Composite Placing Drawings ... 623 Steel ... 623 Lubricant ... 623 Special Fabrication Requirements for PTFE Sliding Bearings . bApplies to nominal diameter of fastener multiplied by the thickness of the metal. = dead minimum value used in analysis of strength rock. C1 dt = w - c ~ = - t material. 5.3.3 Minimum Coverage A minimum cover shall be provided for the culvert at the gap. 6.2.1 Short Lengths. Capstan=-+long-term rupture strength of the connection and Tdas determined in Article 5.8.6.1.2. An appropriate laboratory testing and interpretation procedure, which is a modification of NCMATest Method SRWU-1 (Simac, et. The effects of soil-structure or rock-structure interaction between the piles and ground, including the effects of the group, shall be accounted for in the design of laterally loaded piles. 567 Identifying Marks ... 72 Allowable Working Stress for Round Timber Piles ... 73 Recommended Values of a and Solr Estimation of Drilled Shaft Side Resistance in Cohesive Soil, Reese and O'Neill(1988) ... 229 EFFECTIVE FLANGE WIDTH ... 84 4.6.5.2.6 Method of Construction ... 341 End Treatment ... The total and differential vertical deformation of a retaining wall should be small for rigid gravity and semi-gravity retaining walls, and for soldier pile walls with a cast-in-place facing. 200 Ties for Horizontal Shear . For foundations on clay soils, possible presence of a shrinkage gap between the soil and the foundation shall be considered. 181 DISTRIBUTION REINFORCEMENT ... 20 OVERLOAD PROVISIONS ... Hydraulic Protection . Lower Side and Backfill or Overfill Material . 2.7.1.1.4 Protrusions or depressions at rail joints shall be acceptable provided theirthickness or depth is no of the rail member or greater than the wall inch, whichever is less. A1 Steam Hammers ... 491 Diesel Hammers ... 10.25 LINKS AND HANGERS 10.25.1 Net Section In pin-connected tension members other than eyebars, the net section across the pin hole shall be not less than 140%, and the net section back of the pin hole not less than 100% of the required net section of the body of the member. If the area of the compression flange is less than the area of the tension flange, the minimum flange width may be based on two times the depth of the web in compression rather than the web depth. - 3.30 -- Section 4 FOUNDATIONS Part A GENERAL REQUIREMENTS AND MATERIALS 4.1 GENERAL Foundations shall be designed to support all live and dead loads, and earth and water pressure loadings in accordance with the general principles specified in this section. 410 16.4.3.2 Soils ... Bolts shall be installed with a hardened washer under the nut or bolt head, whichever is the element turned during tightening. Inspection ... The cross bracing must be anchored in some manner. In order to satisfy this assumption, the shear force in the direct data should be computed along the entire span. (1) Except where the Engineer intends otherwise and so indicates in the contract documents, joints with bolts installed in slotted holes where the force on the joint is in a direction other than normal (between approximately 80 and 100°) to the axis of the slot. Forms ... 490 Casting ... 490 Finish ... 490 Curing and Protection ... 490 . 177 Safety Against Structural Failure ... 633 Marking ... 633 Certification ... 84 4.6.5.2.5 Vertical Ground Movement . Settlement and horizontal movements caused by embankment loadings behind bridge abutments should be investigated. The performance factor for the capacity of an equivalent pier or block failure shall be as provided in Table 4.10.6-2. 314 10.40.2.3 Fatigue ... However, recognition of this significant discrepancy in safety margin for the case of dead load acting alone was apparently made at some point in time since the revised equation did appear in earlier versions of the Standard Specifications. .277 . 132 Seismic Pressure ... 132 Structure Dimensions and External Stability ... 287 xxxi xxxvii CONTENTS Sheet ... FIGURE 2.5 Clearance Diagram for Tunnels-Two-Lane Highway Traffic V B = W Highway Traffic V B =3-4 The roadway width shall be increased at least 10 feet and preferably 12 feet for each additional traffic lane. .93 SPREAD FOOTINGS . Data presentation requirements and methods of data analysis. (1983) 86 HIGHWAY BRIDGES Sockets embedded in alternating layers of weak and strong rock shall be designed using the strength of the weaker rock. E 721 Section 4 FOUNDATIONS 4.6.2 NOTATIONS " The following notations shall apply for the design of drilled shaft foundations in soil and rock: N nondim. In the design of the supporting beams, consideration shall be given to the fact that the loads delivered to the supporting beams are not uniformly distributed along the beams. 10.6.7 The foregoing requirements as they relate to beam or girder bridges may be exceeded at the discretion of the designer. *For considerations to be taken into account when exceeding these limitations, reference is made to "Bulletin No. 19, Criteria for the Deflection of Steel Bridges," available from the American Iron and Steel Institute, Washington, D.C. 10.7 LIMITING LENGTHS OF MEMBERS 10.7.1 For compression members, the slenderness ratio, IUIr, shall not exceed 120 for main members, or those in which the major stresses result from dead or live load, or both; and shall not exceed 140 for secondary members, or those whose primary purpose is to brace the structure against lateral or longitudinal force, or to brace or reduce the unbraced length of other members, main or secondary. The active earth pressure coefficient shall be determined using the Coulomb method as shown in Figure 5.5.2A, but assuming no wall friction (i.e., set 6 = 0). 476 SECTION 1 43 TRENCH EXCAVATION AND BACKFILL GENERAL ... 434 (3) Forces shown are per vertical wall element. 400 Coefficient of Friction ... Service loads for evaluating foundation settlement shall include both the unfactored dead and live loads for piles in cohesionless soils and only the unfactored dead load for piles in cohesive soils. 400 FORCES FROM STREAM CURRENT AND FLOATING ICE, AND DRIFT CONDITIONS ... 493 ... The curves presented indicate the proportional the ultimate side resistance (Qs) and ultimate tip (tons resistance (QT)mobilized at various magnitudes of settlement. 117 Laboratory Testing ... 78 4.6.1 General . C10.38.1 SPLICES, CONNECTIONS, AND DETAILS Table C10J6A Design Strength of Connectors Footnote d has been applied to the shear strength of ASTM A 307 bolts to indicate that the joint length correction factor also applies when determining the shear strength of these bolts. Mid.in Pks E umad T M c L n u Minl.b d u r a Thicknw -- 10.7.2 DMSION I-DESIGN 265 - TABLE 10.3.2A Stress Cycles Main (Longitudinal) Load Carrying Members Truck Lane Type of Road Case ADTT Loading Loading1 Freeways, Expressways, Major Highways, and Streets 2,500 or 2 , 0 0 0 , W more 500,000 Freeways, Expressways, Major Highways, and Streets I1 less than 2,500 100,000 Other Highways and Streets not included 12 Case I or 11 111 , Minimum Service Temperature Temperature Zone Designation 0°F and above - 1°F to - 30°F -31°Fto - 60°F 500,000 100,000 100,000 Transverse Members and Details Subjected to Wheel Loads Case ADTT Truck Loading Freeways, Expressways, Major Highways, and Streets I 2,500 or more over 2,000,000 Freeways, Expressways, Major Highways, and streets I1 less than 2,500 2,000,000 Other Highways and Streets III - Type of Road TABLE 10.3.3A Temperature Zone Designations for Charpy V-Notch Impact Requirements length between panel points or centers of braced points or centers of end connections; for secondary members, the length between the centers of the end connections of such members or centers of braced points. 10.40.3 Plate Thickness Requirements ... 314 10.41 ORTHOTROPIC-DECK SUPERSTRUCTURES ... 314 General ... VERTICAL COMMENT OF Fa Y SRN I U ' . Materials ... C10.45 ASSUMPTIONS C10.39.4.4 Compression Flange Stiffened Longitudinally and Transversely C10.39.4.4.9 See C10.39.4.2.6 above. 473 Column Connections . .78 The vertical confining pressure shall be calculated using the Hinge Height Method as shown in Figure 5.8.7.2A. 328 Design of Connectors ... 12,000 10.32.5.4 Bronze or Copper-Alloy 10.32.5.4.1 Bronze castings, AASHTO M 107 (ASTM B 22), Copper Alloys 913 or 911, or copperAlloy Plates, AASHTO M 108 (ASTM B too), shall be specified. Cyclic Loading . 204 Division I Division I CONTENTS General Requirements ... 645 Types ... as Cases I and II. Cases A and B: span length, in feet, as defined under "Span Lengths" Articles 3.24.1 and 4.8 with 8 = shall be in units of gear of truck (PSsor FZ0). PS = 12,000 pounds for H 15 loading; Ps = 16,000 pounds for H 20 loading. Development of deformed reinforcement shall be conformity with the requirements of Articles 8.24.8.26, and 8.27. 567 Material ... 330 Combined Axial Load and Bending ... 330 Maximum Capacity ... 234 Creep of Concrete ... 133 Corrosion Protection ... 4 HIGHWAY CLEARANCES FOR UNDERPASSES ... 8 Width ... If wall deflections estimated using Figure 5.7.2B are excessive for a particular application, a more detailed analysis using beam on elastic foundation, finite element or other methods of analysis which consider the soil-structure interaction effects of anchored walls may be warranted. *. 512 Lockoff ... 513 MEASUREMENT AND PAYMENT ... 10.9.3 When angles connect to separate gusset plates, as in the case of a double-webbed truss, and the angles are connected by stay plates located as near the gusset as practicable, or by other adequate means, the full net area of the angles shall be considered effective. 620 Oil Impregnated Metal Powder Sintered Material ... 620 18.4.6.2 18.4.7 Special Material Requirements for Disc Bearings ... 620 Elastomeric Rotational Elements ... 496 Timber Piles ... 496 Defective Piles ... Long Rivets . 287 Weld Metal . 3.27.1.2 The following rule for distribution of loads assume that the grid floor is composed of main elements that span between girders, stringers, or cross beams, and secondary elements that are capable of transferring load between the main elements. If the pins are bored, through rods with cap washers may be used. 687 WORKING DRAWINGS ... Values of C, may be estimated from the results of laboratory testing of undisturbed soil samples in the laboratory. Steel Laminated Elastomeric Bearings . See also C10.36.3.2.1 (1997). 10.41.4.7 Diaphragms Joints . SECTION 4A NALYSIS REQUIREMENTS GENERAL ... 551 General ... 404 Chemical and Mechanical Requirements ... In order to use load factor design procedures for the structural design of drilled shafts, the load factor design procedures in Section 8 for reinforced concrete shall be used in place of the allowable stress design procedures. 726 6 d d* 4 a, HIGHWAY BRIDGES = distance from extreme compression fiber = ~ n +b n EI = 6 = fb = to centroid of tension reinforcement, mm. The beam may consist of a wall section, a pile cap or a structural beam. 3.27.3.2.1 Open grid floors shall be designed as continuous, but simple span moments may be used and reduced as provided in Article 3.24.3. 379 Compression Perpendicular to Grain ... ... RFDand RFDshall not be less than 1.0. 5.2.3 Loading 5.2.3.1 Loads Retaining walls shall be designed for the effects of the pertinent loading combinations specified in Article 3.22 and 5.8.1 ... 3 to 5 ... 4 Figure 4.4.7.1.1.1A C-11 (Figure 4.4.7.1.1.1C Figure 4.4.7.1.1.1B) 4.4.7.1.1.4, Hs = 1.8 C 2.0 2.5 4.0 . 3.19 1.2 . 1.2 2.4 C 7.4 C 2.0 2.5.5 4.0 . 1.5 4.13.3.3.2.3 C 7.2 ... 4 Figure 4.13.3.3.4-8 Pile Group in Strong Soil Overlying a Weak or Compressible Soil If a pile group is embedded in a strong soil deposit overlying a weaker deposit, consideration shall be given to the potential for a punching failure of the pile tips into the weaker soil stratum. A, is the maximum wall acceleration coefficient at the centroid of the wall mass. .412 Design Values of Parameters in Bedding Factor Equation ... Rd factor will be 1.0. 94 Deterioration ... 450 Response Modification Factor (R) . 271 BENTS AND TOWERS ... 11 ... 4 GENERAL REQUIREMENTS AND MATERIALS 7.1.1 7.1.1 7.1.2 7.1.3 7.1.4 7.2 GENERAL ... Distribution ... 10.18.2.2.1 As a minimum, in the case of the strength design method, the splice plates on the controlling flange shall be proportioned for a design force, PC. The controlling flange shall be taken as the top or bottom flange for the smaller section at the point of splice, whichever flange has the maximum ratio of the elastic flexural stress at its mid-thickness due to the factored loads to its maximum strength. Malleable Castings. 450 . 4.13.3.4b Group Uplift Capacity See Article 4.12.3.3.7b. 92 HIGHWAY BRIDGES 4.9 DEFINITIONS Batter Pile-A pile driven at an angle inclined to the vertical to provide higher resistance to lateral loads. 611 FramedBen ts ... 2.7.1.3.1 Traffic railings should provide a smooth, continuous face of rail on the traffic side with the posts set back from the face of rail. Wasserman TEXAS, Mary Lou Ralls U.S. DOT 620 18.4.7.1 18.4.7.2 18.4.8 Special Material Requirements for Guides . 10 HIGHWAY CLEARANCES FOR DEPRESSED ROADWAYS ... 10 x x CONTENTS Roadway Width ... 10 Clearance between Walls ... 10 Curbs ... 10 30.5 DIVISION I-DESIGN - 287 - 10.30.5 End Floor Beams 10.30.8 Stay-in-Place Deck Forms There shall be end floor beams in all square-ended trusses and girder spans and preferably in skew spans. 216 PROTECTION AGAINST CORROSION ... 349 Settlement Limits ... 349 Footing Reactions (Arch Structures) ... 350 Soil Envelope Design ... 350 Construction Requirements ... 350 Service Requirements ... 350 End Treatment Design ... 406 Chemical Composition ... 406 Minimum Mechanical Properties of Flat Pipe Before Cold Forming ... 406 . The allowable settlement of MSE walls is limited by the longitudinal deformability of the facing and the performance requirements of the structure. segmental c o n c r e t e facing blocks) i t may be desirable t o include the f a c i n g dimensions and weight in s l i d i n g and overturning calculations (1.8. 424 DIVISION 1A SEISMIC DESIGN SECTION 1-INTRODUCTION Figure 1-A Figure 1-B Design Procedure Flow Chart ... 442 Sub Flow Chart for Seismic Performance Categories B, C, D(105 100,000 psi, Y,P. Min. Footing Design ... 213 Minimum Reinforcement ... Structural design of the footings shall be based on the base of the wall foundation with the center of the foundation for foundations on soil and within B/4 of the center of the foundation for foundations on rock where B is the width of the wall base. The lowest backfill reinforcement layer shall not be located above the long-term ground level in front of the wall. The critical sections for shear in the footing shall be taken at a distance d (d = effective depth) from the face of the stem for the toe section and at the back of the stem for the heel section. The magnitude and location of resultant loads and resisting forces for permanent walls shall be determined using the appropriate load combinations specified in Article 3.22. For walls with stiff in-situ conditions where vertical elements embedded in soil and rock for lateral support may be determined using the earth pressure distributions presented in Figures 5.6.2A and 5.6.2C, or other earth pressure distributions developed for use in the design of such walls. 647 .. The values given in Table 4.11.4.2.4-1 are directly applicable to working stress procedure, i.e., all the load factors shall be taken as unity. 410 16.4.4.2 Loads ... 4.4.5.3 Footing Excavations Footing excavations below the ground water table, particularly in granular soils having relatively high permeability, shall be made such that the hydraulic gradient in the excavation bottom is not increased to a magnitude that would cause the foundation soils to loosen or soften due to the upward flow of water. For shafts supported on or extending into rock, a minimum of 10 feet of rock core, or a length of rock core equal to at least three times the shaft diameter for isolated shafts or two times the maximum shaft group dimension for a shaft group, whichever is greater, shall be extended below the anticipated shaft tip elevation to determine the physical characteristics of rock within the zone of foundation influence for design. 568 ... 576 Ix h CONTENTS 11.5.1 Bolted Parts ... 576 11.5.3 Preassembly of Field Connections ... 576 . ABBREVIATIONS AASHTO ACI AISC AITC ASCE ASME ASTM AWS! AWS AWPA CRSI CSI NCHS NFPA PM SAE SSPC WPA WRI WWPA -American Association of State Highway and Transportation Officials -American Concrete Institute -American Institute of Steel Construction -American Institute of Timber Construction -American Society of Civil Engineers -American Society of Mechanical Engineers -American Society for Testing and Materials -American National Standards Institute -American Welding Society -American Wood Preservers Association -Concrete Reinforcing Steel Institute -Commercial Standards -National Forest Products Association -Rubber Manufacturers Association -Society of Automotive Engineers -Steel Structures Painting Council -Western Pine Association -Wire Reinforcement Institute -Western Wood Products Association 50 AASHTO STANDARD SPECIFICATIONS TABLE OF CONTENTS DIVISION I-DESIGN SECTION 1 GENERAL PROVISIONS DESIGN ANALYSIS AND GENERAL STRUCTURAL INTEGRITY FOR BRIDGES ... 576 11.5.3.2 Bolted Connections ... These pullout calculations assume that the long-term strength of the reinforcement (see Article 5.8.6.1) in the resistant zone is greater than T,. 4.6.5.6.1 Factors Affecting Laterally Loaded Shafts 4.6.5.6.1.1 Soil Layering The design of laterally loaded drilled shafts in layered soils shall be based on evaluation of the soil parameters characteristic of the respective layers. 30 PART B-COMBINATION OF LOADS 3.22 COMBINATIONS OF LOADS ... 30 PART C-DISTRIBUTION OF LOADS TO STRINGERS. 638 Materials and Construction ... Continuity for pile shall be required. C-7 1 Ibt Details in a Square Column ... 201 Special Provisions for Brackets and Corbels ... The use of presumptive values shall be based on the results of subsurface exploration to identify soil and rock conditions. The maximum friction angle used for computation of horizontal force within the reinforced soil mass shall be assumed to be 34°, unless the specific project select backfill is tested for frictional strength by triaxial or direct shear testing methods, AASHTO T 234 and T 236, respectively. In general, the pseudo-static approach developed by MononobeOkabe may be used to estimate equivalent static forces for seismic loads. Therefore, the local buckling capacity is now tied to the required load rather than the stiffener sizes required by the recommended limits. (The presence of mica tends to increase the volume and compressibility of sand and soft deposits due to bridging action and subsequent flexibility under increased pressure. 588 Forms ... Where a wall supports a bridge structure, the seismic design forces shall also include seismic forces transferred from the bridge through bearing supports which do not slide freely (e.g., elastomeric bearings). 271 27 Single Bents ... 10.23.5 Seal Welds Seal welding shall preferably be accomplished by a continuous weld combining the functions of sealing and strength, changing section only as the required strength or the requirements of minimum size fillet weld, based on material thickness, may necessitate. It should also be mentioned that Reference 11 can provide guidance on unusual cases of mechanical stress that are not covered by equations 356 Footing Reactions ... As a result, the principle of superposition does not apply to stresses. Austin, W. 2.3 J3ICHWAY CLEARANCES FOR BRIDGES 2.3.1 Width The horizontal clearance shall be the clear width and the vertical clearance the clear height for the passage of vehicular traffic as shown in Figure 2.3.1. The roadway width shall generally equal the width of the approach roadway section including shoulders. r t I s acceptable t o include the facing d~mens~ons and weight in sliding, overturning, and bearing capacity c a l c u l a t i o ns ... 683 28.2.5.3 3.23 28.2.6 28.2.7 28.2.8 SECTION 29 EMBEDMENT ANCHORS 29.1 29.2 29.3 29.4 29.5 29.6 29.7 ISBN: 156051-171-0 AMERICAN ASSOCIATION OF STATE HIGHWAY ... 2.7.3.2.3 Posts The design load for the posts shall be a transverse load of wL (where L is the post spacing) acting at the center of gravity of the upper rail or, for high rails, at 5 feet maximum above the riding surface. Code: HB-17 ISBN: 1-56051-171-0 AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS EXECUTIVE COMMITTEE 2001-2002 VOTING MEMBERS President: Brad Mallory, Pennsylvania Vice President: James Codell, Kentucky Secretary/Treasurer: Larry King, Pennsylvania Regional Representatives: Region I: Joseph Boardman, New York, One-Year Term James Weinstein, New Jersey, Two-Year Term Region 11: Bruce Saltsman, Tennessee, One-Year Term Fred Van Kirk, West Virginia, Two-Year Term Region 111: Kirk Brown, Illinois, One-Year Term Henry Hungerbeeler, Missouri, Two-Year Term Region IV: Joseph Perkins, Alaska, One-Year Term Tom Stephens, Nevada, Two-Year Term NON-VOTING MEMBERS Immediate Past President: E. r r 2 ~ ~ y-n) 1 2 when KLIf ES. 400 10.32.6.2 The above bridge seat unit stress will apply only where the edge of the bridge seat projects at least 3 inches (average) beyond the edge of shoe or plate. Placing Culverts-General . The bearing capacity shall be determined using the strength of the weaker soil stratum. This approach is also recommended by AASHTO Subcommittee on Materials of those changes made to AASHTO M 294 that are recommended in NCHRP Report 429. Backfill . ksi) . 104 4.13.3.3.8a Cohesive Soil ... 600 Facing for Concrete ... 607 6007 MATERIALS ... Thus, it is recommended that the lower limit be eliminated in the Standard Specifications as well. As a result of this stipulation, the minimum longitudinal reinforcement will likely need to be extended beyond the dead-load points of contraflexure. The hardened deck concrete in conjunction with the cross bracing provides bracing against lateral deflection of the top flange. Accuracy of Driving . 494 Determination of Bearing Capacity ... 494 494 General ... 3,000 Shear ... Uplift shall be considered when the force effects calculated based on the appropriate strength limit state load combinations are tensile. and Expansion Rockers ... 257 Fasteners-Rivets and Bolts ... 682 Acceptance Testing . 682 Measurement and Payment ... 638 STONE AND BRICK RAILINGS ... 538 Texturing ... Methods of analysis evaluating the ultimate capacity or deflection of laterally loaded shafts (e.g., Broms, 1964a,b;Singh, et al., 1971) may be used for preliminary design only as a means to determine approximate shaft dimensions. The main members, i.e., the members that span between the supports, shall be designed for the total live load moment. The allowable axial load applied to the pile shall not exceed the value which is required for the stability of the structure. Bearing capacity of piles shall be YN of the distance along the bar between its connections for single lacing and Ym for double lacing. Such theories are based on soil and rock parameters measured by in situ and/or laboratory tests. 192 CONCRETE ... Structural design of the wall facing may also be required. 379 Shear Parallel to Grain ... Husan, T. TEMPORARY WORKS ... 483 Description ... 120.4.6.2 10.24.8 Long Rivets Rivets subjected to calculated stress and having a grip in excess of 4%diameters shall be increased in number at least 1% for each additional %6 inch of grip. 183 Division I Division I CONTENTS Solid Wall Piers ... 4.6.7.3 Load Test Method Selection of an appropriate load test method shall be based on an evaluation of the anticipated types and duration of loads during service, and shall include consideration of the following: The immediate goals of the load tests (i.e., to proof test to some specified load for a shaft group as well as other arrangement of the long-term effects on one another), back-to-back walls, or walls which vary significant sections. If the concrete deck is assumed to be fully effective in negative moment regions, more than half of the web will typically be in compression increasing the susceptibility of the web to bend buckling. 10.56.1.4 Slip-Critical Joints Slip-critical joints shall be designed to prevent slip at the design load and overloads as specified in Article 10.57. The procedures for MSE wall design are sound but not necessarily precise. 576 11.5.4.2 Solid Floor Slabs ... 504 SOIL PRESSURES ... 494 ... The allowable settlement of MSE walls is limited by the longitudinal deformability of the facing and the performance requirements of the structure. Provisions shall be made against any overturning of the longitudinal and shoring. 533 Design Requirements ... 532 Concrete Exposed to Salt Water ... 488 Deterioration ... In metal less than 3⅛ inch thick, countersunk fasteners shall not be assumed to carry stress. The revised bolt limits are expressed in terms of the tight bolt thickness. 342 Flexibility Factors ... 343 Minimum Cover . a Except that the weld size need not exceed the thickness of the thinner part joined. Van Horn. 10.24.3.4 Irrespective of the tightening method, hardened washers shall be used under both the head and the nut when the ASTM A 490 bolts are to be installed in material having a specified yield point less than 40 ksi. If the surcharge is greater than 10-foot ... 10.8.5 For stiffeners and other plates, refer to "Plate Girders" (Article 10.34). 557 . 39 Other Stages ... 683 ... 386 Pipe Requirements ... 451 Distribution of Forces ... 4.6.3.1.1 Design Mechanical Properties, refer to Division I. 31.3 4.4.7 Basic ... 4.6.7.2 Retaining Walls ... Articles 4.6.5.1.1 and 4.6.5.1.2) = influence coefficient for rockdocketed shafts loaded in compression, nondim. Refer to Article 5.6.3. 5.7.6.1 General 5.7.6 Anchor Design Refer to Article 5.6.6 of Division I-A for guidance regarding design of anchored retaining walls subjected to dynamic loads. 4.4.7.2.3 Wall Shoes. 614 10.30.1 ... Bolted parts shall be protected from dirt and water as far as practicable, and the design shall be such that water will not be retained and that the roller nests may be inspected and cleaned easily. They apply to ordinary highway bridges and supplemental specifications may be required for unusual types and for bridges with spans longer than 500 feet. Pins shall be of sufficient length to secure a full bearing. Where combined horizontal and vertical displacements are possible, horizontal movement shall be limited to 1.0 inch or less. ... 150 ... 12.5 ... Articles 4.6.5.2.1 4.6.5.2.2 4.6.5.2.2 Elastomeric Properties at Different Hardnesses . Use the lower of Ten + s t the boss of the weld or Ten p s t the lowest reinforcement layer for continuous r e i n f orcements. 205 Balanced Strain Conditions ... COMMENTARY TO SECTION 17--SOIL-REINFORCED CONCRETE STRUCTURES INTERACTION SYSTEMS C17.6.4.7, C17.7.4.7, and C17.8.5.7 Consideration of thrust in determining flexural stresses under service load conditions can have a significant effect on reinforcing requirements to meet the provisions of Section 17; however, the equations to make this calculation are not commonly available. 105 4.12.4.1 Buckling of Piles ... If no steel to contact in this case be prevented through the placement of a nonconductive material between the soil reinforcement face connection and the facing concrete reinforcing steel. 293 Cast Steel and Ductile Iron ... The anchor bolt length shall be considered in the design check of the connection of continuous twill laminated floor and interconnected nail laminated panel floor, with adequate shear transfer between panels**: 15 inches plus thickness of floor, but not to exceed panel width. 4.6.6.2 Reinforcement Where the potential for lateral loading is insignificant, drilled shafts need be reinforced for axial loads only. BACKFI LLSTRUCTURAL KEY R E R K E CONCRETE BASE BASE SHEAR KEY Figure 5.5.5A Wall on Sloping Rock Foundation Gravity and Semi-Gravity Retaining Walls Fy Compression - ROCK OR FOUNDATION SOIL 4.10.2 Tables 5.5.5A 5.5 Strength Limit Reference Soil Backfill Type ... Retaining Walls Soil Type and Condition acting at the mid-height of the wall where K is equal to K, or K., depending on wall restraint. As of this writing, there is no equivalent metric specification. Load Effect-The force in a foundation system (e.g., axial force, sliding force, bending moment, etc.) due to the applied loads. ASTM C 1372 contains the acceptance criteria for dry-cast concrete blocks, but is not as stringent as desired. In lieu of more exact methods, "J" may be estimated using the following equation: 3.24.3 (3.24.10) DIVISION I-DESIGN For Non-voided Rectangular Beams, Channels, Tee Beams: J = [C(1/3)bt3(1 - 0.630t/b)] where, b = the length of each rectangular component within the section, t = the thickness of each rectangular component within the section. The influence of discontinuities on shaft behavior will be dependent on their attitude, frequency and condition, and shall be evaluated on a case-by-case basis as necessary. 10.9.4 Lug angles may be considered as effective in transmitting stress, provided they are connected with at least one-third more fasteners than required by the stress to be carried by the lug angle. 602 MEASUREMENT AND PAYMENT ... 3rd Ed., p. 2.2.2 Roadway Width For recommendations on roadway widths for various volumes of traffic, see AASHTO A Policy on Geometric Design of Highways and Streets, or A Policy on Design Standards-Interstate System. CONN., David Lenhardt N.J. TURNPIKE AUTHORITY, Richard Raczynski NY STATE BRIDGE AUTHORITY, William Moreau PORT AUTH. One plate on each side shall be as wide as the outstanding flanges will allow. C10.30.8 Stay in-PlaceDeck Forms C10.30.8.2 Metal Stay-in-Place Forms Editorial revisions are made to this article. FOUNDATION AND ABUTMENT DESIGN REQUIREMENTS FOR SEISMIC PERFORMANCE CATEGORIES C AND D ... 468 General ... 156 HIGHWAY BRIDGES Soil should be collected for chemical, electrochemical, and in-ground temperature requirements provided these records of the backfill material characteristics are provided. 10.32.3.3 In determining whether the bolt threads are excluded from the shear planes of the contact surfaces, thread length of bolts shall be calculated as two thread pitches greater than the specified thread length as an allowance for thread runout. Rock anchor Zones - S e effective 3.24.3.1 Case A-Main Reinforcement Perpendicular to Traffic (Spans 2 to 24 Feet Inclusive) The live load moment for simple spans shall be determined by the following formulas (impact not included): HS 20 Loading: + ( ) P, = Moment in foot - pounds (3 - 15) per foot - width of slab HS 15 Loading: (l' Pl, = Moment in foot - pounds (3 - 16) perfoot-widthofslab In slabs continuous over three or more supports, a continuity factor of 0.8 shall be applied to the above formulas for both positive and negative moment. 10.19 STRENGTH OF CONNECTIONS 10.19.1.3 Members, including bracing, preferably shall be so connected that their gravity axes will intersect in a point. 233 Anchorage Bearing Stress ... 65 Summary of Elastic Moduli for Intact Rock, Modified after Kulhawy(1978) ... For steel reinforcement, the required sacrificial thickness shall be provided in addition to the required structural reinforcement thickness to compensate for the effects of corrosion. 4.5.2 Deep Foundation Where subsurface units will be supported on deep foundations, the minimum depth of the subsurface exploration shall extend below the anticipated bearing level a minimum of two footing widths for isolated, individual footings where L 5 2B, and four footing widths for footings where L > 5B. The settlement in Figure 4.6.5.5.1.1A incorporates the effects of elastic shortening of the shaft provided the shaft is of typical length

(i.e., D < 100 ft). For pitch of fasteners in the ends of compression members, see Article 10.16.13. 4.4.2 4.4.4 Soil and Rock Property Selection Soil and rock properties defining the strength and compressibility characteristics of the foundation materials are required for footing design. The limit state for settlement shall be based upon rideability and economy. 3.24.6.2 Where the length of the slab exceeds 1% times its width, the entire load shall be carried by the transverse reinforcement. 10.32.3.1.7 The percentage of unit stress increase shown in Article 3.22, Combination of Loads, shall apply to allowable stresses in bolted slip-critical connections using high-strength bolts, except that in no case shall the percentage of allowable stress exceed 133%, and the requirements of Article 10.32.3.3 shall not be exceeded. Half of this force shall be applied in the plane of each flange. P, is located at the centroid of the structure mass. 415 .16.4.6.1 Application ..... The active earth pressure shall not be less than 0.25 times the effective overburden pressure at any depth. When both edges of the web are in compression, k shall be taken equal to 7.2. 10.34.3.2.2 Where the calculated bending stress in the flange equals the allowable bending stress, the thickness of the web plate in a symmetrical girder stiffened with transverse stiffeners in combination with one longitudinal stiffener located a distance Dl5 from the compression flange shall not be less than (where the Y.P. is for the flange material) 36,000 psi, Y.P. Min. 10.25.3 Size of Pins Pins shall be proportioned for the maximum shears and bending moments produced by the stresses in the members connected. 533 General ..... 611 Concrete Pedestals . 10.18.5.2 Welded field splices preferably should be arranged to minimize overhead welding. A first order estimate of lateral deformation of the entire wall structure, however, can be accomplished as shown in Article 5.8.10. General Requirements . Protection of Concrete .....487 Removal .....487 TEMPORARY WATER CONTROL SYSTEMS ..... 200 Special Provisions for Slabs and Footings .....200 Special Provisions for Slabs of Box Culverts . For piles bearing on rock, a minimum of 10 feet of rock core shall be obtained at each exploration location to insure the exploration has not been terminated on a boulder. .87 Figure 4.6.5.5.1.1B Load Transfer in Tip Bearing Settlement Drilled Shafts in Cohesive Soil, after Reese and O'Neill(1988) .....87 Figure 4.6.5.5.1.2A Load h n s f e r in Side Resistance Versus Settlement Drilled Shafts in CohesionlessSoil, after Reese and O'Neill(1988) ..... 69 End Bearing Piles ..... - Concrete ..... 635 Joint Seal Assemblies . 529 ; liv Evaluation of Concrete Strength . If the shaft has an enlarged base, Q, shall be determined in conformance with Article 4.13.3.3.6. 4.13.3.2 Movement Under Serviceability Limit State 4.13.3.2.1 General The provisions of Article 4.12.3.2.1 shall apply as applicable. (c) 6 in. i ..... 657 DESCRIPTION ..... 83 4.6.5.2.3 Enlarged Bases ..... However, in many cases, the stiffener is not required to support any axial compression. 212 PART D-REINFORCEMENT REINFORCEMENT OF FLEXURAL MEMBERS . Protective Treatment . Holes for high-strength bolts or rivets andlor open holes not exceeding 1% inches, may be neglected provided the area removed from each flange does not exceed 15% of that flange. Natural stream meanders should be studied and, if necessary, channel changes, river training works, and other construction that would reduce erosion problems and prevent possible loss of the structure should be considered. Permits for the construction of crossings over navigable streams must be obtained from the U.S. Coast Guard and other appropriate agencies. The stresses in and the design of the wall facing shall be computed in accordance with the requirements of Article 5.6.6. All components of the anchored wall system shall be checked for the various earth pressure distributions and other loading conditions which will exist during the course of construction. 197 Shear . 76 Splices ..... 10.33.2 Bearing Stiffeners Suitable stiffeners shall be provided to stiffen the webs of rolled beams at bearings when the unit shear in the web adjacent to the bearing exceeds 75% of the allowable shear for girder webs. 5.7.2 DIVISION I-DESIGN 135 DISTANCE FROM EXCAVATION DEPM OF EXCAVATION CURVE I = Sand If = CURVE IIt = CURVE CURVE Z !I Stiff to very hard clay Soft to medium clay, factor of Safety against basal heave Equal to 2.0 = Soft to medium clay, factor of Safety against basal heave Equal to 1.2 (, yu) H + q FIGURE 5.7.2B Settlement Profiles Behind Braced or Anchored Walls Modified after Clough and O'Rourke (1990) Anchored walls with one level of anchors may be designed using a triangular earth pressure distribution in accordance with Article 5.6.2 or using another suitable earth pressure distribution consistent with the expected wall deflection. 10.16.9.3 The separate segments of tension members composed of shapes may be connected by perforated plates or by stay plates or end stay plates and lacing. Prestressed Concrete Piles . 5.6.3 Water Pressure and Drainage 5.6.6 Structure Design Flexible cantilevered walls shall be designed to resist the maximum anticipated water pressure. 447 IMPORTANCE CLASSIFICATION ..... 5.7.6.2 DIVISION I-DESIGN TABLE 5.7.6.2A 137 Presumptive Ultimate Values of Load Transfer for Preliminary Design of Anchors in Soil Modified after Cheney (1982) Relative Density1 Consistency(') Soil Type Estimated Ultimate ~ransferLoad (kipstlineal foot) Loose Medium dense Dense Loose Medium dense Dense Loose Medium dense Dense Stiff Hard Sand and Gravel Sand Sand and Silt Silt-clay M,ixturewih Minimum LL, PI, and LI Restrictions, or ~ i n~ei c a c e o u s (~) ~or a nSilt d Uixtures (''Values corrected for overburden pressure. 428 Span Length ....., ...428 Strength-Reduction Factor .....428 Crack Control ..... 88 Groundwater .....88 Scour ..... Monitoring by an experienced and trained person should always include a thorough examination of the sides and bottom of the excavation, with the possible addition of pits or borings to evaluate the geological conditions. The design values listed are for bolts up to 1 inch diameter. -233 Shrinkage .....90 Splices .....90 . The portion of the load assigned to each main element shall be applied uniformly over a length equal to the rear tire width (20 inches for H 20, 15 inches for H 15). LOChTlW OF MSULTWT ' 8 SW CKXNTS -1 W.*& w * c n o ASSWING P 0., tFOn ME ON SOIL) C II TOE1 -&b 44 FOUNOaTlON LOaOlNES To daurmtna allowabla roundauon lood~nqs,rarer to h r t i c l a 4.4 (Spraod Footings). 41 Open Floors .....41 DISTRIBUTION OF LOADS FOR BENDING MOMENT . The value selected for T*, shall be the minimum average roll value (MARV) for the product to account for statistical variance in the material strength. The maximum moment is for a wheel position assumed to be centered between the supports. 620 18.4.6.1.2 Rolled Copper-Alloy ..... use '8' ln lieu o f 'L'l. If the bearing stratum is a cohesive soil which overlies a stiffer cohesive soil, refer to Figure 4.4.7.1.1.7B to determine N,. .9 Pedestrian Railing, Bicycle Railing . If estimated or actual movements exceed these levels, special analysis and/or measures shall be considered. 377 Sizepactor, C ..... Horizontal measurements of roadway curbs are from the bottom of the face, or, in the case of stepped back curbs, from the bottom of the lower face. 4.6.6 Structural Design and General Shaft Dimensions 4.6.6.1 General Drilled shafts shall be designed to insure that the shaft will not collapse or suffer loss of serviceability due to excessive stress andlor deformation. Printed in the United States of America. 70 Factors Affecting Axial Capacity ..... Allowable Stresses . Hooks and Bend Dimensions ..... .591 Protection of Public and Property .....591 Protection of the Work ..... 574 Q p e of Heating ..... The design of members for bents and towers is governed by applicable articles. When chemical wastes are suspected, a more thorough chemical anal- TABLE 4.10.6-2 Performance Factors for Geotechnical Strength Limit States in Axially Loaded Piles Performance Factor Method/SoiYCondition Ultimate bearing capacity of single piles Skin friction a-method $-method A-method End bearing Clay (Skempton, 1951) Sand (Kulhawy, 1983) & from CPT & from SIT Rock (Canadian Geotech. Greater reinforcementlengths may also be required for very soft soil sites and to satisfy global stability requirements. 497 Method of Measurement ..... 340 Materials ..... 391 391 Mating Surface ..... 229 Segmental Box Girders ..... For this exception, particular care should be taken to provide sufficient preheat to ensure weld soundness. .212 Serviceability Requirements .....212 Application ..... 4.12.4 Structural Design The structural design of driven piles shall be in accordance with the provisions of Articles 4.5.7, which was developed for allowable stress design procedures. 108 4.13.4 Structural Design ..... The performance factor for the group capacity of an equivalent pier or block failure shall be as provided in Table 4.10.62 for both cases of the cap being in contact, and not in contact with the ground. Notations ..... To account for the decreasing stress with increased depth below a footing, and variations in soil compressibility with depth, the compressible layer should be divided into vertical increments (i.e., typically 5 to 10 feet for most normal width footingsfor highway applications), and the consolidation settlement of each increment analyzed separately. J. For unstable or marginally stable ground masses, the design earth pressure may exceed those shown in Figure 5.7.2A and loads should be estimated using methods of slope stability analysis which incorporate the effects of anchors or which consider interslice equilibrium and provide information on interslice forces. 4.10.4 Strength Requirement Foundations shall be proportioned by the methods specified in Articles 4.11 through 4.13 so that their design strengths are at least equal to the required strengths. 6'/l shall be limited to 0.005 for simple span bridges and 0.004 for continuous span bridges (Moulton, et al., 1985). Even with product specific test results, RFm and RFDshall be no less than 1.1 each. Substructure Design ..... 3) Polymer Requirements: Polymers which are likely to have good resistance to long-term chemical degradation shall be used if a single default reduction factor is to be used, to minimize the risk of the occurrence of significant long-term degradation. Primarily, the specifications set forth minimum requirements which are consistent with current practice, and certain modifications may be necessary to suit local conditions. 502 Reinforcing Steel Cage Construction and Placement .....502 Concrete Placement, Curing, . 4.6.6.2.6 Reinforcement into Superstructure Sufficient reinforcement shall be provided at the junction of the shaft with the superstructure to make a suitable connection. HLoading .....21 HS Loading .....21 IMPACT .....21 Application ..... Rail elements spacings shall conform to Articles 2.7.2.2.2and 2.7.3.2.1. NOMENCLATURE: w = Pedestrian or bicycle loading per unit length of rail L = Post spacing FIGURE 2.7.4A Pedestrian Railing, Bicycle Railing 2.7.3.1.1 DIVISION I-DESIGN pedestrian traffic. .411 16.4.4.2.3 Live Loads .....412 16.4.4.3 Minimum Fill .....412 16.4.4.4 Design Methods ..... Injection of Grout . 435 Smooth wall PE pipe requirements . 1.6.2 Blast Protection On bridges over railroads with steam locomotives, metal likely to be damaged by locomotive gases, and all concrete surfaces less than 20 feet above the tracks, shall be protected by blast plates. 409 16.4.2.1 Concrete ..... Bedding . Daniel Davis ARKANSAS, Phil Brand CALIFORMA, Richard Land COLORADO, Mark A. 399 PEPandCDP .....399 FGP and Steel Reinforced Elastomeric Bearings . The slip resistance of the connection shall be computed from Equation (10-172). and J. 349 Foundation Design ..... Other revisions are made to clarify the existing provisions. 201 STRENGTH DESIGN METHOD (Load Factor Design) . 5.8 MECHANICALLY STABILIZED EARTH (MSE) WALL DESIGN MSE walls shall be designed for external stability of the wall system as well as internal stability of the reinforced soil mass behind the facing. .244 Approximate Methods .....244 Limitations .....244 Compressive Stresses ..... 85 4.6.5.3.3 Factors Affecting Axial Capacity in Rock ..... A similar revision has been implemented in Article 4.5.3.2.2b of the AASHTO LRFD Bridge Design Specijications. Placement of the concrete deck in stages can also produce negative moments during construction in regions where the concrete deck has hardened that are primarily subject to positive dead load moments in the final condition. If there is a second line of fasteners uniformly staggered with those in the line adjacent to the free edge, at a gage "g" less than 1%inches 4t therefrom, the staggered spacing in two such lines, considered together, shall not exceed 4 inches + 4t - 3gl4 or 7 inches, but need not be less than one-half the requirement for a single line, t = the thickness in inches of the thinner outside plate or shape, and g = gage between fasteners in inches. The smallest angle used in bracing shall be 3 by 2Y2inches. The portion of the connection embedded in the concrete facing shall be designed in accordance with Article 8.31. 424 Design . 177 Sliding ..... ; ..... 272 Design Strength ..... 3.24.5.1.2 Case B-Reinforcement Parallel to TrafJic The distribution width for each wheel load on the element parallel to traffic shall be as follows: E = 0.35X + 3.2, but shall not exceed 7.0 feet (3-18) The moment per foot of slab shall be (PIE) X footpounds. ARE PER -1mAL 4. where Q = the prying tension per bolt (taken as zero when negative); T = the direct tension per bolt due to external load; a = distance from center of bolt to edge of plate in inches; b = distance from center of bolt under consideration to toe of fillet of connected part in inches; t = thickness of thinnest part connected in inches. In new designs where an exceptionally wide box flange is required, it may indeed become necessary to provide more than two longitudinal stiffeners. A paragraph is added to the end of this article indicating that the web thickness requirements specified in Articles 10.48.5.1,10.48.6.1,10.49.2, and 10.49.3.2(b)arenot to be applied to the constructibility load case. 10.13.2 Partial length welded cover plates shall not be used on flanges more than 0.8 inches thick for nonredundant load path structures subjected to repetitive loadings that produce tension or reversal of stress in the member. 10.32.5.1.2 When in contact with castings - or steel of a different yield point, the allowable unit bearing stress of the material with the lower yield point shall govern. 591 Color .....591 PAINTING METAL STRUCTURES .....591 Coating Systems and Paints ..... The gage of fasteners is the distance in inches between adjacent lines of fasteners or the distance from the back of angle or other shape to the first line of fasteners. 423 16.4.7 Development of Quadrant Mat Reinforcement . b'lt 50,000 psi, Y.P. Min. 9') - 8 Y ' = EFFECTIVE U N I T WE1 GHT 9' = EFFECT1 VE ANGLE OF INTERNAL F R I C T I O N 8 = ANGLE OF WALL F R I C T I O N B = SLOPE ANGLE 9 = (SEE TABLE 5 . ;. The following allowable stresses in pounds per square inch shall be used: Tension ..... Downdrag loads shall not be combined with transient loads. E = ratio of depth of equivalent compression = = = = = = = = = = zone to depth from fiber of maximum compressive strain to the neutral axis, nondimensional (Article 8.16.2.7) c o d 0 1 1factor related to unit weight for concrete (Articles 8.15.5.4 and 8.16.6.4) coefficient of friction, nondimensional (Article 8.15.5.4.3) tension reinforcement ratio = A,/b,d, A,M, nondimensional compression reinforcement ratio = ~:/bd, nondimensional reinforcement ratio producing balanced strain conditions, nondimensional (Article 8.16.3.1.1) ratio of volume of spiral reinforcement to total volume of core (out-to-out of spirals) of a spirally reinforced compression member, nondimensional (Article 8.18.2.2.2) ninforcement ratio used in Equation (8-4) and Equation (8-48), nondimensional moment magnification factor for members braced against sidesway to reflect effects of member curvature between ends of compression member, nondimensional moment magnification factor for members not braced against sidesway to reflect lateral drift resulting from lateral and gravity loads, nondimensional m g t h reduction factor, nondimensional (Article 8.16.1.2) HIGHWAY BRIDGES 729 730 HIGHWAY BRIDGES APP. If the underlying soil stratum consists of a weaker compressible soil, considerationshall be given to the potential for large settlements in that weaker layer. + + 10.24.6.2 Stitch Fasteners In built-up members where two or more plates or shapes are in contact, stitch fasteners shall be used to ensure that the parts act as a unit and, in compression members, to prevent buckling. C-129 C10.49.2 Singly Symmetric Sections with Transverse Stiffeners The word 'unsymmetrical' is replaced with the words 'singly symmetric' in the heading to this article. 569 Workmanship and Finish ..... Uplift forces can be caused by lateral loads, buoyancy effects, and expansive soils. .61 Allowable Contact Stress for Footings on Rock with Tight Figure 4.4.8.1.1A Discontinuities, Peck, et al. Multiple Structures ..... 313 10.40.2.2 Shear ..... 4.2.3 Soil, Rock, and Other Problem Conditions Geologic and environmental conditions can influence the performance of foundations and may require special consideration during design. 4.4.7.2.5 Tolerable Movement Tolerable movement criteria (vertical and horizontal) for footings shall be developed consistent with the function and type of structure, anticipated service life, and consequences of unacceptable movements on structure performance. These requirements result in an allowable tensile stress for steel strip reinforcement, in the wall backfill away from the wall face connections, of 0.55FYFor grid reinforcing members connected to a rigid facing element (e.g., a concrete panel or block), the allowable tensile stress shall be reduced to 0.48Fy.Transverse and longitudinalgrid members shall be sized in accordance with AASHTO M 55 (ASTM A 185). 509 Tendon Insertion ..... 185 Loading ..... The soil parameter used in the analysis shall be representative of the soil shear strength under the considered loading and subsurface conditions. 2.7.1.3.3 Transverse loads on posts, equal to P, or CP, shall be distributed as shown in Figure 2.7.4B. Kelly, Joseph Zitelli BUREAU OF INDIAN AFFAIRS, Wade Casey MILITARY TRAFFIC MANAGEMENT COMMAND, Robert D. Rolled beams with riveted cover plates shall be designed on the same basis as riveted plate girders. 67 ... Dl207 100,000 psi, Y.P. Min. Adopted and Published by the American Association of State Highway and Transportation Officials 444 North Capitol Street, N.W., Suite 249 Washington, D.C. 20001 ,' O Copyright 2002 by the American Association of State Highway and Transportation Officials. 659 Welding ..... Reinforcement . 71 Lateral Loads on Piles ..... Finish ..... 271 General ..... 485 Construction . 4.00 For wheel loads in other positions on the span, the lateral distribution for shear shall be determined by the method prescribed for moment. Drilled shaft displacement analyses shall be based on the results of in-situ and/or laboratory testing to characterize 88 HIGHWAY BRIDGES 4.6.5.5.3 1.4 - 12 - ----- Range of Re¶ults lor Deflralon-Softdng Rerponu Range of Re~ults Trend Cine Trend Line o 0.0 a0.2 1RI 10.8 10.8 'l.0 1l2 11.4 1l.8 41.8 20 t 1 Settlement , Oiameter of Shaft FIGURE 4.6.5.5.1.2A Load Tkansfer in Side Resistance Versus Settlement Drilled Shafts in Cohesionless Soil After Reese and O'Neill(1988) the load-deformationbehavior of the foundation materials. Bottom Struts ..... If smaller spacings are required, + 138 HIGHWAY BRIDGES consideration can be given to differing anchor inclinations between alternating anchors. Shafts shall be designed to resist failure following applicable procedures presented in Section 8. 132 .. 40 Distribution of Bending Moments in Continuous Spans . Where curb and gutter sections are used on the roadway approach, at either or both ends of the bridge, the curb height on the bridge may equal or exceed the curb height on the roadway approach. 184 Collision ..... 271 Batter ..... M. Asphalt Membrane Waterproofing System . 10.16.14.2 The net width for any chain of holes extending progressively across the part shall be obtained by deducting from the gross width the sum of the diameters of all the holes in the chain and adding, for each gage space in the chain, the quantity: f/8 10.17 BENTS AND TOWERS 10.17.1 General Bents preferably shall be composed of two supporting columns, and the bents usually shall be united in pairs to form towers. E HIGHWAY BRIDGES 739 740 HIGHWAY BRIDGES APP. Oeterrnlne K Pullout: Note: H - =~,.Z,.and from Figure 5.8.4.1C. 2.5.4 Curbs The width of curbs shall be not less than 18 inches. .I51 Parameters for Metal Reinforcement Strength Calculations .....I53 Parameters for Geosynthetic Reinforcement Strength Calculations .....,154 Determination of Hinge Height for Segmental Concrete Block Faced MSE Walls .....I59 Seismic External Stability of a MSE Wall .....I62 Seismic Internal Stability of a MSE Wall ..... .478 Approval of Foundation ..... 171 External Stability ..... 299 10.35 TRUSSES . 329 Partially Braced Members ..... ; . 423 16.5.2.2 Reinforcement ..... Wall application limits, soil aggressiveness, polymer requirements, and the calculation of long-term reinforcement strength are specifically described as follows: 1) Structure Application Issues: Identification of applications for which the consequences of poor performance or failure are severe shall be as described in Article 5.1. In such applications, a single default reduction factor shall not be used for final design. 105,No. ST9, Sept. 611 Plank Floors ..... 3.25.23 For longitudinal flooring the span shall be taken as the clear distance between floor beams plus onehalf the width of one beam but shall not exceed-the clear span plus the floor thickness. 516 Structural Steel ..... Straightening Material .....571 Bolt Holes ..... 578 578 11.5.6.1 General ..... 198 Shear in Tension Members . 639 Asphalt ..... 160 Corrosion Issues for MSE Facing Design .....161 .. L Driving .....493 . MSE walls behave as a gravity wall, deriving their lateral resistance through the dead weight of the re- inforced soil mass behind the facing. The thickness of closed ribs in orthotropic decks shall not be less than y16 inch. 294 10.34.2 Flanges ..... 5.23 Soil, Rock, and Other Problem Conditions Geologic and environmental conditions can influence the performance of retaining walls and their foundations, and may require special consideration during design. Bearing elements on the vertical support elements or facing of the wall transfer wall loads to the anchors. When AASHTO M 253 (ASTM A 490) bolts over 1 inch in diameter are to be used in long slotted holes in external plies, a single hardened washer conforming to ASTM F 436 but with %6 inch minimum thickness shall be used in lieu of washers or bars of structural grade material. S W OF FOXES m l O l n C RESISTwtE TO SLlOING. 340 Abrasive or Corrosive Conditions .....341 Minimum Spacing ..... Mpras UTAH, David Nazare VERMONT, James McCarthy VIRGINIA, Malcolm T. Structural Standards ..... .96 Presumptive Allowable Bearing Pressures for Spread Footing Foundations, Modified after U.S. Department of the Navy, 1982 ..... 308 308 10.39.4.1 Tension Flanges ..... 331 Connectors . The serviceability limit state is not specifically evaluated in current practice to design backfill reinforcement for internal stability. Paxson, E. 10.24.5.2 Minimum Spacing of Fasteners The minimum distance between centers of fasteners in standard holes shall be three times the diameter of the fastener but, preferably, shall not be less than the following: For 1-inch fasteners, 3% inches For %-inch fasteners, 3 inches 283 For %-inchfasteners, 2% inches For %-inch fasteners, 2f/4inches 10.24.5.3 Minimum Clear Distance Between Holes When oversize or slotted holes are used, the minimum clear distance between the edges of adjacent bolt holes in the direction of the force and transverse to the direction of the force shall not be less than twice the diameter of the bolt. l a .1 Division I DESIGN Section 1 GENERAL PROVISIONS 1.1 DESIGN ANALYSIS AND GENERAL STRUCTURAL INTEGRITY FOR BRIDGES 1.3 WATERWAYS 1.3.1 General The intent of these Specifications is to produce integrity of design in bridges. 378 Beam Stability Factor, CL ..... The distribution given includes the effect of wheels on parallel elements. g see-also Article 10.32.4. This shall apply to pins used primarily in axially loaded members, such as truss members and cable adjusting links. The following allowable stresses in pounds per sauare inch shall be used: Bending in Extreme Fiber . 597 MANUFACTURE OF STONE FOR MASONRY .....598 General ..... Slip-critical joints are defined as joints subject to stress reversal, heavy impact loads, severe vibration or where stress and strain due to joint slippage would be detrimental to the serviceability of the structure. RE twt UTIVE m AT-RST E& ON mcr OF WL. The lateral earth pressure coefficient ''K'is determined by applying a multiplier to the active earth pressure coefficient. 10.17.4 Bracing 10.17.4.1 Towers shall be braced, both transversely and longitudinally, with stiff members having either welded, high-strength bolted or riveted connections. .229 . Cross frames on horizontally curved steel girder bridges shall be designed as main members with adequate provisions for transfer of lateral forces from the girder flanges. 385 NOTATIONS ..... 426 Concrete ..... Lacing Bars .....270 Gusset Plates .....270 Half-Through Truss Spans ..... 285 Thickness and Net Section . For elements between 27 and 42 inches above the walking surface, elements shall be spaced such that an eight-inch sphere will not pass through any opening. (6) Joints in which, in the judgment of the Engineer, any slip would be critical to the performance of the joint or the structure and so designated on the contract plans and specifications. 4.13.3.3.5 Load Test Where necessary, a full scale load test or tests shall be conducted on a drilled shaft or shafts to confirm response to load. - - Range of Results Trrnd Line Range of Results .--- Trend Line Settlement , Dlameter of Shaft FIGURE 4.6.5.5.1.1A Load Transfer in Side Resistance Versus Settlement Drilled Shafts in Cohesive Soil After Reese and O'NeiU (1988) 0 1 2 3 4 5 6 7 8 9 1 0 Settlement of Base , % Mametar of Base FIGURE 4.6.5.5.1.1B Load Transfer in Tip Bearing Settlement Drilled Shafts in Cohesive Soil After Reese and O'Neill(1988) 4.6.5.5.1.3 Mixed Soil Projile The short-term settlement of shafts in a mixed soil profile may be estimated by summing the proportional settlement components from layers of cohesive and cohesionless soil comprising the subsurface profile. Dimensions and Tolerances . Ellipse and Underpass Shapes) .....667 SECTION 27-CONCRETE CULVERTS Table 27.5A Table 27.5B Table 27.5C Standard Embankment Installation Soils and Minimum Compaction Requirements .....675 Standard ' h n c h Installation Soils and Minimum Compaction Requirements .....676 Equivalent USCS and AASHTO Soil Classifications or SIDD Soil Designations .....677 APPENDICES: A-Live Load Tables ..... 3.24.8 Longitudinal Edge Beams 3.24.8.1 Edge beams shall be provided for all slabs having main reinforcement parallel to traffic. 377 Allowable Stress ..... .410 16.4.4.1 General Requirements ..... 4.4.7.2.3 Consolidation Settlement The consolidation settlement of footings on saturated or nearly saturated cohesive soils may be estimated using FIGURE 4.4.7.2.18 Boussinesg Vertical Stress Contours for Continuous and Square Footings Modied after Sowers (1979) 4.4.7.2.3 59 DIVISION I-DESIGN TABLE 4.4.7.2.2A Elastic Constants of Various Soils Modified after U.S. Department of the Navy (1982) and Bowles (1982) Estimating Es From N(') Typical Range of Values Soil Type Young's Modulus, Es (ksf) Clay: Soft sensitive . (See Division 11, Article 7.3.6.3.) Temporary applications not having severe consequences should poor performance or failure occur, nonaggressivesoils, and polymers meeting the requirements listed in Table 5.8.6.1.2A, provided product specific data is not available. The members shall be connected at their intersections. 528 . 107 4.13.3.2.2 Tolerable Movement ..... Design Strength-The maximum load-carrying capacity of the foundation, as defined by a particular limit state. .4. .448 . The influence of discontinuities on the failure mode shall also be considered. (c) Slabs supported on timber stringers. Rusch, Veldo Goins OREGON, Mark E. 317 Braced Noncompact Sections ..... Safety requirements. .570 Plates ..... .625 WovenPTFEFabric ..... 'C = length in inches, of unsupported flange between lateral connections, knee braces, or other points of support. 603 ..... 215 Seismic Requirements .....216 LIMITS FOR SHEAR REINFORCEMENT ..... 485 Division 11 Division II CONTENTS Design ..... The proposed revisions incorporate equations taken from ACI SP-3, 1965 and make them readily available to design engineers. 195 PART C-DESIGN GENERAL ..... 625 Sealing Rings ..... -10 Vehicular Railing ..... If various parts of the structure are supported individually, the individual supports are known as spread footings, and the foundation is called a footing foundation. 10 Curbs ..... 72 Division I Division I CONTENTS Expansive Soil ..... Note that the environment at the wall face connection may be different than the environment away from the wall face in the wall backfill. 62 62 4.4.8.1.1 Footings on Competent Rock ..... ASTM D 4355 Polyethylene Polyester Polyester All Polymers All Polymers Test Method Criteria to Allow Use of Default RF* Min. 10.29.6.2 The following are the minimum requirements for each bearing: For rolled beam spans the outer beams shall be anchored at each end with 2 bolts, 1 inch in diameter, set 10 inches in the masonry. Fncuis defined as follows: Fncu= Rc, (If,,, / Rl) 2 0.75aFfl (10 - 4c) where: Ru= the absolute value of the ratio of Fcuto fcufor the 10.18.2.2 Flange Splices Fcu = 273 (10 - 4b) where: a = 1.0 except that a lower value equal to (MUMy) may be used for flanges in compression at sections where Muis less than My. controlling flange. .I24 Computational Procedures for Passive Earth Pressuresfor Vertical WaU with Sloping Backfill (Caquot and Kerisel Analysis), M d e d afkr U.S. Department of Navy (1982) ..... 566 General ..... 77 Column Action ..... 394 Piston .....394 LateralLoads ..... 4.12.3.1.3 Effect Of Settling Ground and Downdrag Forces Possible development of downdrag loads on piles shall be considered where sites are underlain by compressible clays, silts or peats, especially where fill has recently been 4.12.3.1.3 DIVISION I-DESIGN placed on the earlier surface, or where the groundwater is substantially lowered. ~ e w k r k BuUetin ; 315, "Moments in Simple Span Bridge Slabs with Stiffened Edges," by Vernon P. 599 CONSTRUCTION .....599 Weather Conditions .....599 Mixing Mortar ....501 Permanent Casing Construction Method ..... 10.19.3.2 Vertical connection plates such as transverse stiffeners which connect diaphragms or cross frames to the beam or girder shall be rigidly connected to both top and bottom flanges. This article is used to compute the maximum bending for the limit state of lateral-torsional buckling, strength, Mu, as indicated by the new language added to Article 10.48.4.1. The bracing must provide restraint against both lateral displacement and twisting of the cross section. 4.6.5.6.1.6 Combined Axial and Lateral Loading The effects of lateral loading in combination with axial loading shall be considered in the design. Channel openings and clearances shall conform in width, height, and location to all federal, state, and local requirements. Basing the slenderness ratio on the full flange width is easier and is consistent with the computation of this ratio in the ASD SpeciJications,the LRFD Specifications and the AISC Specifications. Also, language has been added to indicate that the 10% redistribution of moment is not permitted for compact sections of AASHTO M 270 Grade HPS70W (ASTM A 709 Grade HPS70W) steel. 295 10.34.3 Thickness of Web Plates ..... For this latter case, the simplified earth pressure distributions shown in HIGHWAY BRIDGES 130 5.6.2 1. 86 4.6.5.5.1 Shafts in Soil . Precast Reinforced Concrete Box Sections . .487 . F . 427 Materials ..... DESIGN DISPLACEMENTS FOR SEISMIC PERFORMANCE CATEGORY A .....457 FOUNDATION AND ABUTMENT DESIGN REQUIREMENTS FOR SEISMIC PERFORMANCE CATEGORY A .....457 STRUCTURAL STEEL DESIGN REQUIREMENTS FOR SEISMIC PERFORMANCE CATEGORY A .....458 xlv xlvi ~i\risioiL&-. 669 Reinforced Concrete Culverts .....669 Joint Sealants . Borrow pits should not be located in areas which would increase velocities and the possibility of scour at bridges. 4 YMBOLS AND DEFINITIONS SECTION 2 2.1 NOTATIONS . For footings on rock, the location of the resultant Time factor, T FIGURE 4.4.7.2.3D Percentage of Consolidation as a Function of Time Factor, T EPRI (1983) 62 HIGHWAY BRIDGES of pressure (R) on the base of footings shall be maintained within Bl4 of the center of the footing. 4.12.3.3.9 Batter Pile The bearing capacity of a pile group containing batter piles may be estimated by treating the batter piles as vertical piles. Long slotted holes may be used in one of the connected parts at any individual faying surface without regard for the direction of applied load on connections which satisfy the requirements of Article 10.32.3.2.1 or Article 10.57.3.1, as applicable. 555 . 27 Forces Applied Directly to the Substructure .....27 Overturning Forces ..... 429 Structure Backfill .....429 Scour Protection ..... =oft and broken rock, not including shale. 2.7.2.2.3 The minimum design loadings for bicycle railing shall be w = 50pounds per linear foot transversely and vertically, acting simultaneously on each rail. 78 4.5.21.1 Materials . For temporary structures (i.e., design lives of 3 years or less), the allowable ten- The allowable tensile load per unit of reinforcement width for geosynthetic reinforcements for permanent structures (i.e., design lives of 75 to 100 years) is determined as follows: (See Figure 5.8.6B.) where, FS is a global safety factor which accounts for uncertainties in structure geometry, fill properties, externally applied loads, the potential for local overstress due to load nonu~formities,and uncertainties in long-term reinforcement strength. Seepage shall be controlled by installation of a drainage medium (e.g., preformed drainage panels, sand or gravel drains or wick drains) behind the facing with outlets at or near the base of the wall. 616 Certificate of Compliance .....616 MEASUREMENT AND PAYMENT .....616 SECTION 18-BEARINGS . 26 Group 111 and Group VI Loadings ..... 1974). 429 SECTION 17SOIL-THERMOPLASTIC PIPE INTERACTION SYSTEMS 17.1 17.1.1 17.1.2 17.1.3 GENERAL ..... 4.11.3.4.2 Settlement of Footings on Cohesive Soils For foundations on cohesive soils, both immediate and consolidation settlements shall be investigated. 81 4.6.5.1.3 Tip Resistance in Cohesive Soil . 249 SECTION 1eSTRUCTURAL STEEL PART A . However. Lower right-hand picture courtesy of William Oliva and Scott Becker. As a result of the revisions to the area requirement for transverse stiffeners in the new Equation (10-106a) (see the earlier discussions on the revisionsto Article 10.34.4.7), the previous Equation (10-104) has been replaced with a revised upper limit of 16 on the slenderness ratio in new Equation (10-105). 402 Anchorage ..... C10.56.1 Connectors C10.56.1.3 Bolts and Rivets This editorial revision eliminates the reference to Table 10.57A in the definition for the design shear strength of a rivet or bolt, F,. 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. 554 Prestressing Steel and Anchorages ..... For drilled shafts which extend through or below sloping ground, the potential for additional lateral loading shall be considered in the design. 670 Precast Reinforced Concrete Circular Arch and Elliptical Pipe . The language indicates that singly symmetric and unsymmetric compression members, such as angles or tees, and doubly symmetric compression members, such as cruciform or builtup members with very thin walls, may be governed by the modes of flexural-torsional buckling or torsional buckling rather than the conventional flexural buckling mode reflected in the equations given in the table. To address at least some of these issues, this revision states that the minimum 1% longitudinal reinforcement be placed wherever the longitudinal tensile stress in the deck due to either the construction loads or the design loads exceeds the allowable tensile stress for the concrete, f,, specified in Article 8.15.2.1.1. In addition, the required longitudinal reinforcement is to be No. 6 bars or smaller spaced at not more than 12 inches to ensure adequate distribution of the reinforcement to control the crack size. Definitions . 381 Column Stability Factor, C, ... *Thisshear transfer may be accomplished using mechanical fasteners, splines, or dowels along the panel joint or spreader beams located at inte~valsalong the panels or other suitable means. End-Bearing Splices . 637 637 Materials and Fabrication ..... 10.34.3.1.2 Where the calculated compressive bending stress in the flange equals the allowable bending stress, the thickness of the web plate (with the web stiffened or not stiffened, depending on the requirements for transverse stiffeners) shall not be less than (where the Y.P. is for the flange material) 36,000 psi, Y.P. Min. 627 . 32 Interior Stringers and Beams ..... 355 SECTION 13-WOOD STRUCTURES Figure 13.7.1A Untitled ..... Records of the control investigations should be kept as part of the final project data, among other things, to pennit a later assessment of the foundation in connection with rehabilitation, change of neighboring structures, etc. Shafts designed to bear on strata in which the rock surface is inclined should extend to a sufficient depth to that the shafttip is N1y on the Shafts designed to bear on rock strata in which bedar ding planes are not perpendicul the shaft axis extend aminimum of 2B the d i p p a strata to the potential for shear along natural bedding planes and other slippage surfaces associated with stratification. 3.24.5.2 Railing Loads Railing loads shall be applied in accordance with Article 2.7. The effective length of slab resisting post loadings shall be equal to E = 0.8X 3.75 feet where no parapet + 3.24.5.2 -- - DIVISION I-DESIGN - . To address at least some of the issues discussed above under ASD Article 10.38.4.3, it is proposed that the minimum one-percent longitudinal reinforcement be placed wherever the longitudinal tensile stress in the deck due to either the construction loads or the overload specified in Article 10.57 exceeds 0.9fr, where f, is the modulus of rupture for the concrete specified in Article 8.15.2.1.1. The factor 0.9 represents a conservative resistance factor applied to the modulus of rupture to provide additional assurance against concrete cracking. .507 WORKING DRAWINGS ..... Additionally, these sacrificial thickness requirements are not applicable in applications where: the MSE wall will be exposed to a marine or other chloride rich environment; the MSE wall will be exposed to stray currents such as from nearby underground power lines or adjacent electric railways; the backfill material is aggressive; or the galvanizing thickness is less than specified in these guidelines. Fracture on the net section is conservatively checked using 0.46Fu(which represents 0.55 times the ratio of the AISC resistance factor of 0.75 for net section fracture divided by the AISC resistance factor of 0.90 for gross section yielding). If the unsupported length of the edge of the gusset plate (or solid web) exceeds 60 times its thickness, the plate or web shall have a stiffening plate or angles connected along its unsupported edge. -56 Figure 4.4.7.1.1.7B Modified Bearing Capacity Factor for Two-Layer Cohesive Soil with Softer Soil Overlying Stiffer Soil, EPRI (1983) ..56 Figure 4.4.7.1.1.8A Definition Sketch for Footing Base Inclination .....57 Figure 4.4.7.2.1A Boussinesg Vertical Stress Contours for Continuous and Square Footings, Modified after Sow

the elastic flexural stress at its midthickness to its allowable stress. 183 Settlement .... 4.12.3.1.4 Uplift Pile foundations designed to resist uplift forces should be checked both for resistance to pullout and for structural capacity to carry tensile stresses. Encapsulation Protected Ground Anchor Tendon . 686 SECTION 30-THERMOPLASTIC PIPE GENERAL .... 687 Description .... 687 Workmanship and Inspection .... 504 Measurement .... 516 Structure Backfill Material .... 3.24.10.2 The amount of distribution reinforcement shall be the percentage of the main reinforcement steel required for positive moment as given by the following formulas: For main reinforcement parallel to traffic, 100 Percentage = -Maximum 50% & (3 - 21) For main reinforcement perpendicular to traffic, Percentage Maximum where, S = the effective span length in feet. Department of Navy (1982) .... 10.16.11 Gusset Plates 10.16.11.1 Gusset or connection plates preferably shall be used for connecting main members, except when the members are pin-connected. Similarly, the ASD web shear buckling check for constructibility in this article implicitly assumes that a load factor of approximately 1.75 (0.58f0.33) is applied to the unfactored dead loads. 22 Figures "olwEl'R3 rigures Figure 3.7.6B Figure 3.7.7A Lane Loading .... 23 Standard HS Trucks .... The language in this footnote is parallel to the language added in a similar footnote to ASD Table 10.32.1A (see earlier discussion of the revisions to Table 10.32.1A). Lower Side and Backfill or Overfill .... 677 Cover Over Culvert During Construction .... 678 MEASUREMENT .... 678 PAYMENT .... 678 SECTION 28-WEARING SURFACES DESCRIPTION .... 679 LATEX MODIFIED CONCRETE TYPE WEARING SURFACE . Stream crossings should be located with regard to initial capital cost of bridgeworks and the minimization of total cost including river channel training works and the maintenance measures necessary to reduce erosion. C11.3.2.5 Alternative Fasteners Reference to the ASTM F 1852 Specification has been added. --Yin." 'Ri3 Cn ON Bending Moment In calculating bending moments in glued laminated timber longitudinal decks, no longitudinal distribution of wheel loads shall be assumed. 6 . 286 Pedestals and Shoes .... 405 . Critical Section . 213 Distribution of Reinforcement .... Special attention shall be given to footings on fill. "Tun p s I f o r continuous s o i l reinforcements (e.g. .... 637 Construction . 165 Traffic Loads and Barriers .... 0 end a l l ohmr verrpblms defrned i n Frgurm 5.5.2A : (b) Extensible Rernf orcements FIGURE 5.8.5.1A Location of Potential Failure Surface for Internal Stability Design of MSE Walls 5.8.6 151 DIVISION I-DESIGN Default Values f o r Pullout FrLction Factor, F a 20t/S 0. Sections of partially braced members must also satisfy the compression-flange slenderness requirement given by the revised Article 10.48.2.1(a). Spans 51 to 100 feet; 2 bolts, 1% inches in diameter, set 12 inches in the masonry. Normal to the direction of flow of thrust of plank, but not less than 10 inches. Performance Factor A factor used to modify a nominal resistance, which accounts for the uncertainties associated with the determination of the nominal resistance and the variability of the actual capacity. Limit State-A limiting condition in which the foundation and/or the structure it supports are deemed to be unsafe (i.e., strength state), or to be no longer fully useful for their intended function (i.e., serviceability limit state). 314 10.41.4 10.41.4.1 Local Bending Stresses in Deck Plate .... 314 10.41.4.2 Bending Stresses in Longitudinal Ribs .... 315 10.41.4.3 = 4 = h d i Stresses = 'n Transverse Beams .... 315 10.41.4.4 = intersectionof Ribs, Beams, and Girders .... 315 10.41.4.5 Thickness of Plate Elements .... 315 10.41.4.6 Wearing Surface .... 315 10.41.4.7 Deck and Girder .... 315 10.41.4.8 Maximum Slenderness of Longitudinal Ribs .... 315 . Farrar ILLINOIS, Ralph E. MEASUREMENT . Load tests shall be conducted following prescribed written procedures which have been developed from accepted standards and modified, as appropriate, for the conditions at the site. In the absence of laboratory testing, engineering characteristics may be estimated based on field tests and/or published prop& correlations. .. 392 Design Coefficients of Friction . Stringers supported on the top flanges of floor beams preferably shall be continuous over two or more panels. Limitations for Braced Noncompact Sections . A. = gross area of the member The diameter of the holes shall be taken as specified in Article 10.16.14.6. As a minimum, the connection shall be proportioned to develop the design force through shear in the bolts and bearing at the bolt holes, as specified in Article 10.56.1.3.2 in the case of the strength design method and in Table 10.32.3B in the case of the service load design method. 424 16.6.2.2 Reinforcement . Cole TENNESSEE, Edward P. 105 4.12.5 Construction Considerations .... 33 Total Capacity of Stringers and Beams .... There is no known theoretical reason for this requirement. 258 Untitled .... 181 DISTRIBUTION OF WHEEL LOADS THROUGH EARTH FILLS .... Nelson Hernandez PREFACE to Seventeenth Edition Major changes and revisions to this edition are as follows: 1. Typical continuous vertical wall elements include piles, precast or cast-in-place concrete diaphragm wall panels, tangent piles, and tangent caissons. .327 Diaphragms .... 'Itaffic Loads .... 547 MEASUREMENT and PAYMENT .... 547 Measurement .... 547 . For longer shafts, the effects of elastic shortening may be estimated using the following: pe = PD/AEc (4.6.5.5.1.1-1) For a shaft with an enlarged base in cohesive soil, the diameter of the shaft at the base (Bb) should be used in Figure 4.6.5.5.1-1B to estimate shaft settlement at the tip. Design Load-All applicable loads and forces or their related internal moments and forces used to proportion a foundation. spacing, mm (Article 10.20.2.1) = range of horizontal shear, N/mm (Article 10.38.5.1.1) = section modulus of transverse stiffener, mm3 (Articles 10.39.4.4 and 10.48.6.3) = section modulus of longitudinal or transverse stiffener, mm3 (Article 10.48.6.3) = ultimate strength of the shear connector, N (Article 10.38.5.1.2) = section modulus with respect to the compression flange, mm3 (Table 10.32.1A, Article 10.48.4.1) = computed rivet or bolt unit stress in shear, MPa (Article 10.32.3.3.4) = range in tensile stress, MPa (Table 10.3.1B) Y BRIDGES = direct tension per bolt due to external load, N (Articles 10.32.3 and 10.56.2) = arch rib thrust at the quarter point from dead live impact loading, N (Articles 10.37.1 and 10.55.1) = thickness of the thinner outside plate or shape, mm (Article 10.35.2) = thickness of members in compression, mm (Article 10.35.2) = thickness of thinnest part connected, mm (Articles 10.32.3.3.2 and 10.56.2) = computed rivet or bolt unit stress in tension, including any stress due to (Article prying action, MPa 10.32.3.3.4) = thickness of the wearing surface, mm (Article 10.41.2) = flange thickness, mm (Articles 10.34.2.1, 10.39.4.2, 10.39.4.3, 10.48.1.1, 10.48.2.1, 10.50. Sidewalk Brackets . Providing minimum compression-flange widths that satisfy the recommended limit in these regions will help to ensure a more stable girder that is easier to handle. 319 Transversely Stiffened Girders .... As a minimum, temperature and shrinkage steel shall be provided. > Transition radius 2 I n. 5.5.4 Seismic Pressure Refer to Section 6 of Division I-A for guidance regarding the lateral earth pressure on gravity and semi-gravity retaining walls subjected to seismic loading. 331 Web Plates .... 502 Excavation Inspection .... CR, and CR, shall be determined at the anticipated vertical confining pressure at the wall face between the facing blocks. For consistency with other serviceability checks (e.g. fatigue-see the discussion on revised Article 10.58.1), overload flange stresses caused by loads acting on the appropriate composite section may be computed assuming the concrete deck to be fully effective for both positive and negative moment if: 1) shear connectors are provided along the entire length, and 2) the longitudinal reinforcement satisfies the provisions of Article 10.50.2.3. By providing shear connectors to ensure composite action and by controlling the crack size at overload with the minimum longitudinal reinforcement, it is logical to consider the concrete deck to be effective in tension at overload for loads acting on the appropriate composite section for reasons discussed previously (see discussion on revisions to ASD Article 10.32.1). The minimum bar length shall be the development length of the reinforcement specified in the Article 10.35.2 but not more than 12 inches to ensure adequate distribution of the reinforcement to control the crack size. 218 Positive Moment Reinforcement .... 218 . FABRICATION .... 601 GALVANIZING . 352 Backfill Protection .... 352 Cut-Off (Toe) Walls .... 352 Hydraulic Uplift .... See also C10.48.6.1 (1997). 21 . 285 EYEBARS .... 573 Boring Pin Holes .... 406 . The word 'I-shaped' is also removed since Article 10.51.1 on composite box-girders refers back to the provisions of Article 10.48. The zone of maximum stress is assumed to be located at the boundary between the active zone and the resistant zone. 2.4.3 Curbs Curbs, if used, shall match those of the approach roadway section. 461 Monolithic Abutments .... 128 Expansion and Contraction Joints .... In the absence of laboratory testing, engineering properties may be estimated based on published test results or local experience. 501 Slurry .... 290 Applied Tension, Combined Tension, and Shear . 170 Design for Presence of Obstructions in the Reinforced Soil Zone .... 171 PREFABRICATED MODULAR WALL DESIGN .... 171 Structure Dimensions .... 76 Reinforcement into Superstructure .... 76 Shell Requirements .... 71.2.7.3 Railings other than those shown in Figure 2.7.4B are permissible provided they meet the requirements of this Article. SF = ROADWAY WIDTH AT LEAST 2 FT. In developing the design lateral pressure, the lateral pressure due to traffic, permanent point and line surcharge loads, backfill compaction, or other types of surcharge loads shall be added to the lateral earth pressure in accordance with Articles 3.20.3 and 5.5.2. Flexible cantilevered walls shall be dimensioned to ensure stability against passive failure of embedded vertical elements such that FS 1 1.5. Unfactored dead and live loads shall be used to evaluate the factor of safety against passive failure of embedded vertical elements. In determining the shear resistance, the value of q, for an equivalent soil mass. 51 4.4.7.1.1.3 Inclined Loading .... 381 Netsection .... ttttt FIGURE C4.123.72-2 Uplift of group of closely-spaced piles in cohesionless soils 1 1 l.o - r 0.9 L 8 0.8 0.7 8g - o.6 0.5 0.4 - r+qqq\Sm 03 0 Embedment Ratio HID, FIGURE C13.3.3.4-1 Elastic Settlement Influence Factor as a Function of Embedment Ratio and Modulus Ratio (After Donald, Sloan and Chiu, 1980, as presented by Reese and O'Neill, 1988) FIGURE C4.13.3.3.4-4 Bearing Capacity Coefficient, K, (After Canadian GeotechnicalSociety, 1985) 4.12.3.3.10.4 DIVISION I-DESIGN each pile is estimated with the nominal uplift resistance of the pile group. Design of Bridges .... Group Behavior For piles in cohesive soils the capacity shall be multiplied by an efficiency factor n, where n = 0.7 for a center-to-center spacing of three diameters and n = 1.0 for a center-to-center spacing of six diameters. 10.19.2.4 Where timber stringers frame into steel floor beams, shelf angles with stiffeners shall be provided to carry the total reaction. 2.7.1 Vehicular Railing 2.5.2 Clearance between Walls 7.7.1.1 General The minimum width between walls of two-lane tunnels shall be 30 feet. 4.12.3.3.1 Dynamic/Seismic Design Refer to Division I-A of these Specifications and Lam and Martin (1986a, 1986b)for guidance regarding the de- 105 sign of driven piles subjected to dynamic and seismic loads. 312 Diaphragms .... Minimum Yield Point, psi F = Bearing on Pins notSubject to Rotation, psiC Bearing on Pins Subject to Rotation, psi (such as used in rockers and hinges) A 668 Class C A 668 Class D A 668 Class F A 668* Class G 36,000 33,000 37,500 50,000 50,000 0.80Fy 29,000 26,000 30,000 40,000 40,000 0.40Fy 14,000 13,000 15,000 20,000 20,000 Stress in Extreme Fiber, psi Shear, psi - - -- Maysubstitute rolled material of the same properties. 4.12 DRIVEN PILES 4.12.1 General The provisions of the specifications in Articles 4.5.1 through 4.5.21 with the exception of Article 4.5.6, shall apply to strength design (load factor design) of driven piles. Each member has one vote. In many cases, the required stiffener area is zero indicating that the stiffener is not required to support any axial compression. AND FLOOR BEAMS .... 32 PositionofLoadsforShear .... 80 4.6.5.1.1 Side Resistance in Cohesive Soil .... 284 Design Joints .... 471 STRUCTURAL STEEL DESIGN REQUIREMENTS FOR SEISMIC PERFORMANCE CATEGORIES C AND D . Proportioning .... 653 SURFACE PREPARATION .... 653 Mixing .... Lennard CONNECTICUT, Gordon Barton DELAWARE, Doug Finney, Dennis O'Shea D.C., Donald Cooney FLORIDA, William N. 484 Construction .... Minimum Spacing . 234 Estimated Losses .... 210 Special Provisions for Slabs and Footings .... 210 Special Provisions for Side Walls and Corners .... 211 Special Provisions for Bracket and Corbels .... 211 . Regulations, codes, and standards should, as a minimum, meet the specifications and design standards of the American Railway Engineering Association, the Association of American Railroads, and AASHTO. Smaller fillet welds may be approved by the Engineer based upon applied stress and the use of appropriate preheat. Dasmohapatra MANITOBA, Ismail Elkholy NORTHERN M A M ISLANDS, John C. The limiting flange slenderness ratio of 24 (independent of the yield stress), which corresponds to the upper limit of 24 specified in ASD. The corresponding LFD lateraltorsional buckling check (Article 10.61.3) is made using a load factor of 1.3 applied to the unfactored dead loads. The magnitude of movement required to mobilize passive pressure is a function of the soil type and condition in front of the wall as defined in Table 5.5.2A. 136 Overall Stability .... 138 Anchor Load Testing and Stressing .... 138 Division I Division I CONTENTS MECHANICALLY STABILIZED EARTH WALL DESIGN . 1-113. .... Structural Composite Lumber .... 26 Division I Division I CONTENTS Superstructure Design .... '10.32.3.1.6 DIVISION I-DESIGN Where of joints should be investigated at intermediate load stages especially those joints located in composite regions. 627 Test Pieces to be Supplied to the Engineer . 670 INSTALLATION . The design strength is calculated for each applicable limit state as the nominal resistance, R, multiplied by an appropriate performance (or resistance) factor. Methods for calculating nominal resistance are provided in Articles 4.11 through 4.13, and values of performance factors are given in Article 4.10.6. = The overall stability of slopes in the vicinity of foundations shall be considered as part of the design of foundations. 4.9.2.2 When approved by the Engineer, oversize, short slotted holes or long slotted holes may be used in the following joint detail requirements. Because of the effect of moving live loads, points of deadload contraflexure have little meaning in continuous bridges. If practical, the thickness of the footings shall be maintained constant in each panel or in each group of panels. 1196.4.2 Rotational-CapacityTests .... 579 11.5.6.4.3 Requirement for Washers .... 580 11.5.6.4.5 Calibrated Wrench Method .... 580 11.5.6.4.6 Alternative Design Bolt Installation Method .... 581 11.5.6.4.7 Direct Tension Indicator Installation Method .... 581 11.5.6.4.7a Verification .... Attention is also directed to the following publications prepared and published by AASHTO Guide for Commonly Recognized (CoRe) Structural Elements-1998 Edition AASHTO Guide Specifications for Horizontally Curved Steel Girder Highway Bridges with Design Examples for I-Girder and- Box-Girder Bridges-2002 Edition AASHTO Guide Speci-kations-Thermal Effects in Concrete Bridge Superstructures-1989 Edition AASHTO LRFD Bridge Construction Specifications-1998 Edition AASHTO LRFD Bridge Design Specifications,2nd Edition, SI-1998 Edition AASHTO LRFD Bridge Design Specificlations,2nd Edition, US-1998 Edition AASHTO LRFD Movable Highway Bridge Design Specifications, 1st Edition2001 Edition AASHTO/AWS-D1.5M/D1.5:2001 An American National Standard: Bridge Welding Code and its Commentary-2002 Edition Bridge Data Exchange (BDX) Technical Data Guide-1995 Edition Construction Handbook for Bridge Temporary Works-1995 Edition Guide for Painting Steel Structures-1997 Edition Guide Specifications and Commentary for Vessel Collision Design of Highway Bridges-1991 Edition Guide Specifications for Alternate Load Factor Design Procedures for Steel Beam Bridges Using Braced Compact Sections-1991 Edition Guide Specifications for Aluminum Highway Bridges-1991 Edition Guide Specifications for Design and Construction of Segmental Concrete Bridges, 2nd Edition-1999 Edition Guide Specifications for Design of Pedestrian Bridges, 1997 Edition Guide Specifications for Fatigue Evaluation of Existing Steel Bridges-1990 Edition Guide Specifications for Highway ~ r i d Fabrication ~e with HPS070W Steel2000 Edition Guide Specifications for Seismic Isolation Design, 2nd Edition-1999 Edition Guide Specifications for Strength Evaluation of Existing Steel and Concrete Bridges-1989 Edition Guide Specifications for Structural Design of Sound Barriers-1989 Edition Guide Specifications for Thermal Effects in Concrete Bridge Superstructures-1989 Edition Guide Specifications for Fatigue Evaluation of Existing Steel Bridges-1990 Edition Guide Specifications for Highway Fabrication with HPS070W Steel-2000 Edition Guide Specifications for Strength Design of Truss Bridges (Load Factor Design)-1985 Edition Guide Specifications for Strength Evaluation of Existing Steel and Concrete Bridges-1989 Edition Guide Specifications for Structural Design of Sound Barriers-1989 Edition Guide Specifications for Timber Structures-Laminated Wood Deck-1991 Edition Guidelines for Bridge Management Systems-1993 Edition Manual for Condition Evaluation of Bridges-2000 Edition Movable Bridge Inspection, Evaluation and Maintenance Manual-1998 Edition Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 4th Edition-2001 Edition Additional bridges and structures publications prepared and published by other AASHTO committees and task forces are as follows: Guide Specifications for Cathodic Protection of Concrete Bridge Decks-1994 Edition Guide Specifications for Polymer Concrete Bridge Deck Overlays-1995 Edition Guide Specifications for Shotcrete Repair of Highway Bridges-1998 Edition Inspectors' Guide for Shotcrete Repair of Bridges-1999 Edition Manual for Corrosion Protection of Concrete Components in Bridges-1992 Edition Two Parts: Guide Specifications for Concrete Overlay Pavements and Bridge Deck-1990 Edition AASHTO Maintenance Manual: The Maintenance and Management of Roadways and Bridges-1999 Edition of the Committee since its inception in 1921: The following have = e = ave chairmen Messrs. E.F. Kelley, who pioneered the work of the Committee, Albin L. M, shall be applied at the mid-depth of the web. 685 INSPECTION AND TESTING . 285 Packing of Eyebars .... 328 Maximumspacing .... 513 SECTION 7-EARTH RETAINING SYSTEMS DESCRIPTION .... During the design of the foundations requiring strength, density, and groundwater conditions should be verified during construction, by visual inspection. 658 PAYMENT .... MEASUREMENT AND PAYMENT . 4.6.5.5.1.1 Cohesive Soil The short-term settlement of shafts in cohesive soil may be estimated using Figures 4.6.5.5.1.1A and 4.6.5.5.1.1B. Where no curbs are used on the roadway approaches, the height of the bridge curb above the roadway shall be not less than 8 inches, and preferably not more than 10 inches. An MSE wall with multiple precast concrete panels cannot tolerate as much vertical deformation as flexible welded wire or geosynthetic facings because of potential damage to the precast panels and unsightly panel separation. C10.61.4 Compression-FlangeLocal Buckling The b/t requirement for the compression flange in Equation (10-174) is rewritten in terms of the full flange width b rather than the projecting flange width b'consistent with previous revisions. Superstructure Deflection Limitations .... 483 Removal . 649 Sacked Concrete Riprap .... 369 General Tensioning Requirements . 10.24.3.7 Where AASHTO M 164 (ASTM A 325) bolts of any diameter or AASHTO M 253 (ASTM A 490) bolts equal to or less than 1 inch in diameter are to be installed in a long slotted hole in an outer ply, a plate washer or continuous bar of at least 5⁄16 inch thickness with standard holes shall be provided. (4)q, = Cone penetration resistance &sf). 4.12.3.3.3 Pile of Capacity Estimates Based on In Situ Tests In situ test methods may be used to estimate the ultimate axial capacity of piles. Vertical Reinforcement .... 75 Reinforcement Cover .... 76 Splices .... 10.32.3.3.3 For combined shear and tension in slip-critical joints using high-strength bolts where applied forces reduce the total clamping force on the friction plane, the slip resistance per unit area of bolt, fv,shall not exceed the value obtained from the following equation: where: f, = computed tensile stress in the bolt due to applied loads including any stress due to prying action, ksi; F, = nominal slip resistance per unit of bolt area from Table 10.32.3C, ksi; F, = 120 ksi for M 164 (A 325) bolts up to 1-inch diameter; 10.32.3.4 Fatigue When subject to tensile fatigue loading, the tensile stress in the bolt due to the service load plus the prying force resulting from application of service load shall not exceed the following design stresses in kips per square inch. C10.53.1.3 Partially Braced Members The heading for this article is revised to correspond to the revised heading for Article 10.48.4. The language in this article is also revised for consistency with the revised language of Article 10.48.2.1 (see discussion of revisions to Article 10.48.4.1 for computing the maximum permissible compression-flange capacity for a partially braced member. Where footings with inclined bases are necessary, the following factors shall be applied in Equation 4.4.7.1.1-1: b, = b, - (1 - lyil)tNctan+)(for 4 > 0) (4.4.7.1.1.8-3) b, = [(1 - j2 r (l e 7 --2)] (for 57 + = 0) (4.4.7.1.1.8-3) Refer to Figure 4.4.7.1.1.8A for definition ofeach term. Note that for "Rectangular Beams with Circular Voids" the value of "J" can usually be approximated by using the equation above for rectangular sections and neglecting the voids. PrecastRrestressed Concrete Beams with Wide Top Flanges .... 230 FLANGE AND WEB THICKNESS-BOX GIRDERS . 406 SAFETY FACTORS .... 66 4.4.11.12 Isolated and Multiple Footing Reactions .... As a result of this requirement, the minimum longitudinalreinforcementwill likely need to be extended beyond the dead-load points of contraflexure . ... 176 Safety Against Soil Failure .... 67.0 General . 10.30 FLOOR SYSTEM 10.30.1 Stringers 10.29.6 Trusses, girders, and rolled beam spans preferably shall be securely anchored to the substructure. Section 5 RETAINING WALLS Part A GENERAL REQUIREMENTS AND MATERIALS 5.1 GENERAL Retaining walls shall be designed to withstand lateral earth and water pressures, including any live and dead load surcharge, the self weight of the wall, temperature and shrinkage effects, and earthquake loads in accordance with the general principles specified in this section. 5 . 355 Analytical Basis for Design .... Load Factor Method .... 1.1 Design Analysis When these Specifications provide for empirical formulae, alternate rational analyses, based on theories or tests and accepted by the authority having jurisdiction, will be considered as compliance with these Specifications. 459 Design Forces for Abutments and Retaining Walls .... 460 DESIGN DISPLACEMENTS FOR SEISMIC PERFORMANCE CATEGORY B .... 177 Overall Stability (Revised Article 4.5 Cross Frames .... 278 End Connections of Floor Beams and Stringers .... 279 DIAPHRAGMSAND CROSS FRAMES . (a) Detail thickness 5 0.5 in. 424 16.6.1 Materials . Part B SERVICE LOAD DESIGN METHOD ALLOWABLE STRESS DESIGN 4.4 SPREAD FOOTINGS 4.4.1 General 45 4.4.1.2 Footings Supporting Non-Rectangular Columns or Piers Footings supporting circular or regular polygonshaped concrete columns or piers may be designed assuming that the columns or piers act as square members with the same area for location of critical sections for moment, shear, and development of reinforcement. .566 Eyebars .... 567 Structural Tubing .... The reference to Table 10.32.4.2A should be to Table 10.32.4.3A instead. 197 Flexure .... Reinforcements 157 . Otherwise, shafts shall be designed for a minimum factor of safety 2.5. The minimum recommended factors of safety are based on an assumed normal level of field quality control during shaft construction. 163 Loads .... The dimensional units provided with each notation are presented for illustration only to demonstrate a dimensionally correct combination of units for the footing capacity procedures presented herein. C10.32.3.3 Applied Tension, combined Tension, and Shear (Equation (10-18) was replaced by Equations (10-16) and (10-17) in previous interim specifications and is no longer required. ... 189 . 415 16.6.3 Strength-Reduction Factors . Pecfix defined as follows: where: Rf = the absolute value of the ratio of Frcfto Fcrffor the controlling flange frcf = flexural stress at the mid-thickness of the noncontrolling flange at the point of splice concurrent with fcf in calculating Fcf;Fefand R, holes in the flange subject to tension shall not be accounted for as specified in Article 10.12. 10.16.9.4 The thickness of stay plates shall be not less than %0 of the distance between points of support for main members, and Ym of that distance for bracing members. 453 Special Requirements for Curved Bridges .... 340 Arch Design .... 10.48.7 Shear Stiffeners are not required in this region. Reference to Table 10.32.3B. McGrath, 1999. = TThe total load per unit wall width applied to each layer. For seismic loading, the dimensions of the active zone are the same as for the static loading. 5.2.1.3 DIVISION I-DESIGN N T A L B I N WALL PRECAST CONCRETE B I N WALL 113 PRECAST CONCRETE CRIB WALL GAB1 ON WALL Figure 5.2B Typid Prefabricated Modular Gravity Walls 5.2.1.3 Anchored Walls Anchored walls are typically composed of the same elements as nongravity cantilevered walls (Article 5.2.1 .2), but derive additional lateral resistance from one or more tiers of anchors. .iii ---l--L- - - l - L L- - L L l G - - , u l b 1 i - ,a u a - u wl l L --Iwl -- - - wl l i shear, whichever controls: K = design constant depending on design load as follows: H15 Fb K=0.47 = allowable bending stress, in pounds per square inch, based on load applied parallel to the wide face of the laminations (see Tables 13.2.2Aand B). (b) For the effective deck width. For calculation purposes, the thickness of clear concrete cover used to compute A shall not be greater than 50 mm. 10.18.2.1.5 Fn = allowable bending stress, in pounds per square inch, based on load applied parallel to the wide face of the laminations (see Tables 13.2.2Aand B). Only the effective deck width which extends beyond the theoretical failure surfaces shall be used in this computation. 63 4.4.8.2.2 Footings on Broken or Jointed Rock .... 63 4.4.8.2.3 Tolerable Movement .... 507 MATERIALS .... 679 Water .... Plate load test shall be performed in accordance with the procedures specified in ASTM Standard D 1194-87 or AASHTO Standard T 235. 305 10.38.5.1 10.38.5.1.1 Fatigue . The settlement of groups of drilled shafts shall be estimated using the same procedures as described for pile groups, Article 4.5.12.3.2. -Cohesive Soil, See Article 4.12.3.2.3b 4.13.3.2.4 Lateral Displacement The provisions of Article 4.12.3.2.4 shall apply as applicable. Also, there is a potential for undesirable wall deflection if anchors are not fully stressed when the backfill is only partially complete and provides limited passive resistance. .527 Water Content .... Potential slip of joints should be investigated at intermediate load stages especially those joints located in composite regions. 516 Permeable Material .... 4.13.3.3.6 Uplift Capacity Uplift shall be considered when (i) upward loads act on the drilled shafts and (ii) swelling or expansive soils act on the drilled shafts. 32 Bending Moments in Stringers and Longitudinal Beams .... 32 General .... 10.34.2.1.3 The ratio of compression flange width to thickness shall not exceed the value determined by the formula =- 3y250 but in no case shall 6 (10 - 19) bt exceed 24 10.34.2.1.4 Where the calculated compressive bending stress equals 55 Fy the (bt) ratio for the various grades of steel shall not exceed the following: 36,000 psi, Y.P. Min. 23 Elastic Shortening .... (d) 2 in.> Transition radius 2 0 in. 682 Inst leaki CONTENTS Finishing . 69 Pile Types .... 358 Dimensions .... Article 4.5.6 covers the allowable stress design of 4.12.1 DIVISION I-DESIGN 101 Table 4.12.4.4.2-1 Presumptive Bearing Pressures (tsf) for Foundations on Rock (After Putnam, 1981) Code for Year 1 Bedrock2 Sound Foliated Rock Sound Sedimentary Rock Soft Rock3 Soft Shale Broken Shale Baltimore BOCA Boston Chicago Cleveland Dallas Detroit Indiana Kansas City Los Angeles New York City New York State Ohio Philadelphia Pittsburgh Richmond St. Louis San Francisco Uniform Building Code NBC Canada New South Wales, Australia Note: 1-Year of code or original year and date of revision. The uplift capacity of a belled shaft shall be estimated neglecting the side resistance above the bell, and assuming that the bell behaves as an anchor. 10.56.2 Bolts Subjected to Prying Action by Connected Parts Bolts required to support applied load by means of direct tension shall be proportioned for prying action produced by deformation of the connected parts. 93 Load Combinations and Load Factors .... 93 . The corresponding LFD shear buckling check (Article 10.61.3) is made using a load factor of 1.3 applied to the unfactored dead loads. 677 Overfill .... 477 Precast Reinforced Concrete Box Sections .... For symmetrical girders see Figure 10.34.3.1 .A. 5.6 REINFORCED CONCRETE ALLOWABLE STRESS DESIGN REQUIREMENTS FOR SEISMIC PERFORMANCE CATEGORY C . To reduce this significant inherent conservatism in the ASD constructibility check and make it more equivalent to the LFD check, the current ASD equation for the shear buckling capacity should be multiplied by 1.35 when making this check, which results in the revised Equation (10-57a). -321 SINGLY SYMMETRIC SECTIONS .... 4.6.5.1.3) -> = pullout resistance factor. or more. \f e t & 8 u t S I o l a 5 o " e a P l l " . d : ~ a ~ t d (0 t e e ~ . R v n ~ e (l Rc= where- T, = ~ t ~ r ~ ~ s ~ T, Rc= where - T, = (see A f r i c l e 5.8.6.2.1) Fy R e b allowable long- term tensile s t r e n g t h of reinforcement (s t r e n g t h / u n - i t w r l - r o r c e m e n t widtro FS A Jnc t c o r a f safety (see A r t i c l e 5.8.6.2) Fy = yield strength o f steel R, = re r i n f o r c e m e n t coverage r a t i o (see R = l w r = maximum Tma om - ' unlt b FS = n = b r h continuous r e i n f o r c e m e n t i = c... 535 General .... 4, of each splice plate shall be taken as defined in Article 10.18.2.2.4. As a minimum, the connections for both the top and bottom flange splices shall be proportioned to develop the design force in the flange through shear in the bolts and bearing at the bolt holes, as specified in Article 10.56.1.3.2. Where filler plates are required, the requirements of Article 10.18.1.2.1 shall also be satisfied. 10.8.4 For compression members, refer to "Trusses" (Article 10.16). 529 Mixing .... 4.4.2 Notations The following notations shall apply for the design of spread footings on soil and rock: 4.4.11 Applicability Provisions of this Article shall apply for design of isolated footings, and to combined footings and mats (footings supporting more than one column, pier, or wall). 9 of the box augment.1 wit rh.ro % HA Weight ovo- the bow urrt Hinge Hetght rhm lb= 0 Htnam Hmiailt,, H,,. 595 Surface Preparation .... 595 Paint .... 595 595 Application .... The downdrag loads may be calculated, as specified in Article 4.12.3.2 with the direction of the skin friction forces reversed. 76 General Reinforcement Requirements .... Alternative Construction Methods .... 501 . 3.27.1.3 Reinforcementfor secondary elements shall consist of bars or shapes welded to the main steel. 198 Shear in Beams and One-way Slabs and Footings .... 607 Steel Components .... 607 . Structural Specificationsand Guidelines .... 13 SECTION &LOADS PART A-TYPES OF LOADS NOTATIONS .... 17 GENERAL .... 526 526 Fine Aggregate .... Application Lateral Load Protection, REF. Fillet Welds: Fv = 0.27 F, (10-12) where, Fv = allowable basic shear stress; F, = tensile strength of the electrode classification When detailing fillet welds for quenched and tempered steels-the designer may use electrode classifications with strengths less than the base metal provided that this requirement is clearly specified on the plans. 679 Portlandcement .... Alternately, Table 4.4.8.1.2B may be used as a guide to estimate C, . 7 Navigational . There is no known theoretical reason for using the subpanel depth in these requirements. 326 SECTION 10STRUCTURAL STEEL Table 10.2A Table 10.2B Table 10.3.1A Table 10.32.1A Table 10.32.1A Table 10.32.1C Table 10.32.1B Table 10.32.3B Table 10.33A Table 10.34.2.1A Table 10.32.3A Table 10.33A Table 10.34.2.1A Table 10.32.3C .... The thickness of eyebars shall be not less than K of the width, nor less than ½ inch, and not greater than 2 inches. Wheel loads shall not be applied on sidewalks protected by a traffic barrier. Spacing shall not be greater than 50 mm. 10.18.2.1.5 In the case of the strength design method, the strength of compact sections at the point of splice shall not be taken greater than the moment capacity at first yield, computed by accounting for the holes in the tension flange as specified in Article 10.12. Orthotropic-Deck Superstructure .... 10.18.1.4 Truss Chords and Columns Splices in truss chords and columns shall be located as near to the panel points as practicable and usually on the side where the smaller stress occurs. 1.7 SUPERELEVATION Where required, provisions shall be made for trolley wire supports and poles, lighting pillars, electric conduits, telephone conduits, water pipes, gas pipes, sanitary sewers, and other utility appurtenances. Exposed rail ends, posts, and sharp changes in the geometry of the railing shall be avoided. 484 Deflections .... A new Article 10.41.4.4 is added, which states that longitudinal web stiffeners preferably shall not be located in yielded portions of the web of a hybrid girder. 454 MINIMUM CRITERIA FOR DESIGN OF REFLECTIVE PAVEMENT MARKINGS 10.32.1 Steel Allowable stresses for steel shall be equal to the load factor design 1 % times the maximum width of the member under the maximum pitch is reached. .639 . 1235-1249 467 467 Longitudinal Linkage Forces .... M C r mm DRilrO W I U I e O cnss TO ETERRI #T CRITIUL C-- IITON. 330 Equivalent Moment Factor C . The height of curbs shall be as specified for bridges. General . 4.6.5.6 -- Range of Rasulta fw OtffecUon-Hardening R a = - p o n r Lateral Loading The design of laterally loaded drilled shafts shall account for the effects of soil/rock-structureinteraction between the shaft and ground (e.g., Reese, 1984; Borden and Gabr, 1987). 203 Rectangular Sections with Compression Reinforcement . use "8' i n lieu o f Tan0. 598 Design Methods .... Sheikh-Ibrahim, F. They include: (1) Joints subject to fatigue loading. As a result, excessive reinforcement areas are often specified. Thus, the term 199912000 COMMENTARY C-127 'members' is deemed to be more appropriate than the term 'sections' here. This is especially important where con- Reinforced Sort Mass *r yr IC 5.8.3 5.8.4 Calculation of Loads for Internal Stability Design Reinforcement loads calculated for internal stability design are dependent on the soil reinforcement extens- Retained Fill 3 Yr IC T4 C- 6 C t+ 4 Y = 'or, ~ +pH L * F2 +qHYr C- 1 tl g = Traffic Live Load R = Resultant of Vertical Forces SUMMING MOMENTS ABOUT POINT CT If have concentrated dead loads, such as those illustrated i n figures 5.8.12.1A and 5.8.12.18. 10.32.3.2.1 and 10.57.3.1) number of roadway design lanes (Article 10.39.2) ratio of modulus of elasticity of steel to that of concrete, nondimensional (Article 10.38.1) number of longitudinal stiffeners (Articles 10.39.4.3, 10.39.4.4, and 10.51 S.4) allowable compressive axial load on members, N (Article 10.35.1) axial compression on the member, N (Articles 10.48.1.1, 10.48.2.1, and 10.54.1.2) R MSH2= MC = M, = M= = Mr = Ms Mu = N,&N2 = Nc = NS = Nw = n = n = P = P,P1,P2, &P3 = forceinthslab,N(Article10.38.5.1.2) ps = allowable slip resistance, N (Article 10.32.3.2.1) = maximum axial compression capacity. 4.4.7.2.1 Effective Dimensions .... 55 4.4.7.1.1.8 Inclined Base .... 4.4.5 Distribution of Bearing Pressure Footings shall be designed to keep the maximum soil and rock pressures within safe bearing values. 623 18.4.9 Special Requirements for Bedding Materials .... (4.4.7.1.1.6-2) Undrained Loading (4.4.7.1.1.6-3) for z, 5 0: sw = y ~* Refer to Figure 4.4.7.1.1.6A for definition of terms used in these equations. The thickness of the bottom edge of the enlarged base shall not be less than 6 inches. Sequence of Operations . 554 Bars .... 10.16.10.3 If the distance across the member between fastener lines The flanges is more than 15 inches and a bar with a single fastener in the connection is used, the lacing shall be double and fastened at the intersections. Shelf angles shall be not less than ½ inch thick. However unfactored live loads must be added to the permanent loads when estimating settlement of shafts in granular soil. 105 Pile Group in Strong Soil Overlying a Weak or Compressible Soil .... A provision to check web bend-buckling at overload is added. (5) Joints in which welds and bolts share in transmitting load at a common faying surface. .... 10.16.10 Lacing Bars When lacing bars are used, the following provisions shall govern their design. Water Requirements .... 282 Size of Fasteners (Rivets or High-Strength Bolts) .... 283 283 Spacing of Fasteners .... Extensive references have been made to the Standard [ermal procedure] for Transportation Materials and Methods of Sampling and Testing also published by AASHTO, including equivalent ASTM specifications which have been reproduced in the Association's Standard Specifications by permission of the American Society for Testing and Materials. See 10.32.3.2.3. 292 HIGHWAY BRIDGES Slip Coefficient for Coatings Used in Bolted Joints" as adopted by the Research Council on Structural Connections. .424 16.6.3.3 Strength-Reduction Factors .... 5.5.6 Structure Design Structural design of individual wall elements shall be byservice load or load factor design methods in conformance with Article 3.22. Factors of safety under combined static and seismic loads for pullout and breakage of reinforcement may be reduced to 75% of the factors of safety used for static loading. 66 4.4.11.1.1 Critical Section .... 133 Water Pressure and Drainage .... 392 10.37.1 Moment Amplification and Allowable Stress . End stiffeners shall be provided at supports. 490 . grrrdr end sheets). .435 Corrugated PE pipe requirements .... 11 Refer to Article 1.3.2 and FHWA (1988) for general guidance regarding hydraulic studies and design. 1.3.2.3 Hydraulic Analysis (a) Backwater and mean velocities at bridge opening for various trial bridge lengths and selected discharges. In estimating settlements of drilled shafts in clay, only unfactored permanent loads shall be considered. 354 354 Scour .... 442 Overall and Compound Stability of Complex MSE Wallsystems .... 4.12.3.1 Factors Affecting Axial Capacity See Article 4.5.6.1. 1 The following sub-articles shall supplement Article 4.5.6.1.1. 4.12.3.1.1 Pile Penetration Piling used to penetrate a soft or loose upper stratum overlying a hard or firm stratum, shall penetrate the hard or firm stratum by a sufficient distance to limit lateral and vertical movement of the piles, as well as to attain sufficient vertical bearing capacity. The restraining force must be applied to the flange along some path between its point of connection and that flange. 287 Metal Stay-in-Place Forms .... blt = 17 90.000 psi, Y.P. Min. 181 DEAD LOADS .... Pm may be adjusted for other soil friction angles using the Mononobe-Okabe method, with the horizontal acceleration kh equal to A, and k, equal to zero. 505 Test Shafts .... distance from the girder neutral axis to the extreme outer fiber, mm. N = number of slip planes. Made Continuous . Unfactored dead and live loads shall be used to evaluate factor of safety against passive failure of the embedded vertical elements. 5.8.2.2 Pullout Resistance. of the ratio of horizontal to vertical acceleration, ky (Article 5.2.3.2) Figure 5.2B FIGURE 4.4.7.1.1.7B Typical Two-Layer Soil Profiles FIGURE 4.4.7.1.1.7B Modified Bearing Capacity Factor for Two-Layer Cohesive Soil with Softer Soil Overlying Stiffer Soil Overlying Stiffer Soil FIGURE (1993) 4.4.7.1.1.8 DIVISION I-DESIGN 4.4.7.1.1.8 Inclined Base St = s. Footings with inclined bases are generally not recommended. Anchor bolts shall be swedged or threaded to secure a satisfactory grip upon the material used to embed them in the holes. .623 Grout and Mortar .... Goodpaster LOUISIANA, Hossein Ghara, Mark J. 5.3 Vertical Clearance The vertical clearance between curbs shall be not less than 14 feet. Sui = incremental undrained shear strength a=s S, = w * t e i (~ w) m (t T b s . 11 7 + a ~ w + a tgk Y u P = +N, (Q - B1 = Yi = Axn = n (L A P P. 3.4.1.3. Usually, bridge waterways are sized to pass a design flood of a magnitude and frequency consistent with the type or class of highway. (Article 4.6.5.2.4.1) PC = elastic shortening of shaft, m (Articles P1 = total settlement displacement at butt for (4.6.5.5.1.1-1 and 4.6.5.5.1.2) P1 = u = 0, = 0; = shaft with rock socket, m (Articles P1 = total uplift displacement at butt for shaft with rock socket, in (Equation 4.6.5.5.2-3) 1415- 426 Reinforcement .... 495 Splicing of Piles .... 496 . 456 . flange) = 37.50 ksi - . 495 C-Columns .... Pressure distribution of rigid footings shall be evaluated in conformance with Article 4.4.10. 204 Pure Compression .... 204 Pure Flexure .... 139 External Stability for Wall with Horizontal Backslope and TrafficSurcharge .... Flange stresses are increased by yielding of the web. 432 Construction and Installation . 179 Backfill .... segmental concrete facing blocks) it may be desirable to include the facing dimensions and weight 1 n bearing capacity calculations (1.e.. 434 Local Buckling .... 434 Section Properties .... 434 PE Corrugated Pipes .... 434 PE Ribbed Pipes .... 51 4.4.7.1.1.5 Embedment Depth .... FIGURE 5.8.6A Parameters for Metal Reinforcement Strength Calculations . SECTION 6.4 ROUND ANCHORS DESCRIPTION .... Also, the allowable stress design check contains no provision for inclusion of the web strip when calculating the moment of inertia of the stiffener. For walls with anchors, any downward movement can cause significant distress of the anchors. Longitudinally reinforced slabs shall be designed for the appropriate HS loading. .241 General Design Principles and Detailing Requirements .... 241 Intermediate Anchorages .... 629 Special Test Requirements for Rocker and Roller Bearings .... 629 Special Test Requirements for PTFE Sliding Bearings .... 629 Special Test Requirements for Pot Bearings .... The critical sections for bending moments in footings shall be taken at the face and back of the stem. The performance factors for the ultimate skin friction and ultimate tip resistance, estimated using in situ methods, shall be as provided in Table 4.10.6-2. E = development length, mm (Articles 8.24 through 8.32) = development length of standard hook in tension, mm (Article 8.29) Ldh = development length for hooked bars = development length of standard hook in tension, mm as measured from critical section to outside end of hook (straight embedment length between critical section and start of hook (point of tangency plus radius of bend and one bar diameter), mm (Article 8.29) 0th 0, M = 0 x, applicable modification factor, mm (Article 8.29) = basic development length of compression reinforcement, mm: (Article 8.16.5.2.1) = computed moment capacity, N-mm (Article 8.24.2.3) M, Mb = maximum moment in member at stage for which deflection is W I g computed, N-mm Article 8.13.3) = nominal moment strength of a section at balanced strain conditions, N-mm (Article 8.16.4.2.3) APP. Dorthick, Robert C. (b) Detail thickness 2 1.0 in. For this case, the allowable stresses may be increased 50%. The effective transformed Arc, can be derived as follows: where:. A1, AR A, A = total area of section = area of tension flange = area of web = effective transformed area of compression flange and concrete deck Using the web depth D for simplicity instead of the distance between the centerline of A* and Arcto compute the distance to the neutral axis from the effective top flange, which is equivalent to Dc in this case, gives (referring to Figure 1): Noncompact Sections This article is revised to express the maximum strength of non-compact composite sections in terms of stress rather than moment. WELDING . 3.24.7 Median Slabs Raised median slabs shall be designed in accordance with the provisions of this article with truck loadings so placed as to produce maximum stresses. The American Association of State Highway and Transportation Officials wishes to express its sincere appreciation to the above organizations, as well as to those universities and representatives of industry whose research efforts and consultations have been most helpful in continuing improvement of these specifications. . and Protection .... When the required strength of the splice is greater than the useful capacity of the net section of a splice as determined by the spacing is used to compute j, the smallest possible required moment of inertia results. The Standard Spec$cations for Highway Bridges are intended to serve as a standard or guide for the preparation of State specifications and for reference by bridge engineers. .526 Untitled . The dynamic horizontal thrust Pm is evaluated using the pseudo-static Mononobe-Okabe method and is applied to the back surface of the reinforced fill at a height of 0.6H from the base for level backfill conditions. Calculate the design depth, D 1.2 D to 1.4 D for r safety factor of 1.5 to 2.0. a. The live load bending moment for each panel shall be determined by the following equations: TWO OR MORE TRAFFIC LANES Load Fraction = 3.25:1.5 In addition, the dowels shall be checked to ensure that the allowable stress of the steel is not exceeded using the following equation: wg 1.3.75 +28 =inp whichever is 5.00" greater. excluding aggregate fill. 108 4.13.3.3.6a Uplift Capacity of a Single Drilled Shaft .... 411 4.11.1 Using this: (1) the product of the bearing capacity and an appropriate performance factor exceeds the effect of vertical design loads, and (2) eccentricity of loading, evaluated based on factored loads, is less than ¼ of the footing dimension in any direction for footings on soils. 3 37 860 t = but in no case shall blt exceed 24 where fbis the top fiber compressive stress due to noncomposite dead load. C10.23 WELDING C10.23.2 Effective Size of Fillet Welds C10.23.2.2 Minimum Size of Fillet Welds In the table of minimum fillet weld sizes in this article, the metric thickness of the base metal of the thicker part joined (T) is changed from 19 mm to 20 mm; this increases the range to take into conformance with the requirements of the AWS D1.5 Bridge Welding Code and also with a similar table in the SI Units version of the 2ndEdition of the AASHTO LRFD Bridge Design Specifications (Table 6.13.3.4-1). 515 Segmental Concrete Facing Blocks .... 9 Clearance Diagram for Tunnels-Two-Lane Highway Traffic . 665 Arches .... 665 Anchor Bolts .... 526 Coarse Aggregate .... 612 Composite Wood-Concrete Decks . Standard pile load testing procedures developed by ASTM as specified in Article 4.12.3.3.5 may be employed to determine uplift capacity. Polymers including PVC, HDPE, polypropylene and polyesters meeting the requirements listed in Table 5.8.6.1.2A, provided product specific data is not available Values for WID,&, and RFl, shall be determined from product specific test results. If passive resistance is included as part of the shear resistance required for resisting sliding, consideration shall also be given to possible future removal of the soil in front of the foundation. Calculate the m a x i m bending moment at the point of zero shear. The word 'I-shaped' is removed since the shear provisions in this article also apply to box-girders. Soils shall be considered nonaggressive if they meet the following criteria: pH of 5 to 10 Resistivity of not less than 3,000 ohm-cm Chlorides not greater than 100 ppm Sulfates not greater than 200 ppm 5.8.6.1 Design Life Requirements Reinforcement elements in MSE walls shall be designed to have a corrosion resistance/durability to ensure a minimum design life of 75 years for permanent structures. 492 Pile Drive Head .... 493 Followers .... 493 Leads .... 493 Water Jets .... Settlements of footings on cohesionless soils shall be estimated using empirical procedures or elastic theory. The effect of relatively large vertical spacing of reinforcement on this assumption is not known, and a vertical spacing greater than 0.8 meters (31 inches) shall DMSION I-DESIGN 5.8.4.1 J, . Rernfor cud 147 Assumed only f o r maximum horizontal stress comput~ -ons, not pullout Retained F i l l Y, 337 SOIL-METAL PLATE INTERACTION SYSTEMS .... 337 STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINAIRES, 57 4.4.7.1.2 Factors of Safety .... When subjected to wave impact, the wavelength parallel to the bridge engineering profession during the period of development. Fillers '/4 inch and thicker need not be extended and developed provided that the design shear strength of the fasteners, specified in Article 10.56.1.3.2 in the case of the strength design method and in Table 10.32.3B in the case of the service load design method, is reduced by the following factor R: where: y = A A, 10.17.5 Af = sum of the area of the fillers on the top and bottom of the connected plate A, = smaller of either the connected plate area or the sum of the splice plate areas on the top and bottom of the connected plate 10.17.5 Fillers 10.18.2.2.3 The splice plate for the strength design method and in Table 10.32.3B in the case of the service load design method, for slip-critical connections shall not be adjusted for the effect of the fillers. 688 Trench Width .... Refer to the Manual of Steel Combination . .674 Box Sections, EmbankmentInstallations .... 675 Arch Sections .... 675 Long Span Structures .... 687 . 39 DIVISION II CONTENTS DIVISION II CONTENTS DIVISION II CONSTRUCTION INTRODUCTION .... The diameter of the holes shall be taken as specified in Article 10.16.14.6. In the case of the strength design method, the strength of compact sections in the tension flange shall not be taken greater than the moment capacity at first yield, computed by accounting for the holes in the tension flange as specified in Article 10.12. 428 Distribution of Concentrated Load Effects in Slabs .... 428 Distribution of Concentrated Loads in Skewed Culverts .... 428 Shear Transfer in Transverse Joints Between Culvert Sections .... 420 18.4.6.1 Broome and Copper Alloys . 279 279 General .... Gross section, when compression flange is: (A) Supported laterally its full length 0.55Fy hyembedment in concrete (B) Partially supported or is unsupported50ve 20,000 Up to 4 in. 485 TubeForms . New wording is also added at the beginning of this article to indicate that some of the provisions of the article may be superseded by requirements in subsequent Articles 10.49 through 10.61 dealing specifically with singly symmetric flexural members, composite sections, box-girders, hybrid girders, and constructibility.Additional language is also added to this arti- 199912000 COMMENTARY cle to specify recommended minimum flange proportions for fabricated I-shaped girders. 70 Axial Capacity in Cohesionless Soils . 108, No. ST12, December, 1982, pp. 10.8.2 Where the metal will be exposed to marked corrosive influences, it shall be increased in thickness or specially protected against corrosion. There is insufficient evidence at this time regarding the long-term performance of epoxy coatings for these coatings to be considered equivalent to galvanizing. PAINTING CONCRETE . 5.3 SUBSURFACE EXPLORATION AND TESTING PROGRAMS The elements of the subsurface exploration and testing programs shall be the responsibility of the Designer, based on the specific requirements of the project and his or her experience with local geologic conditions. A parapet or other railing installed at or near the curb line shall have its ends properly flared, sloped, or shielded. An e-mail notification will also be sent to previous purchasers notifying them that a revision is available for download. Camber . 3.28 DISTRIBUTION OF LOADS FOR BENDING MOMENT IN SPREAD BOX GIRDERS** 3.28.1 Interior Beams The live load bending moment for each interior beam in a spread box beam superstructure shall be determined by applying to the beam the fraction (D.F.) of the wheel load (both front and rear) determined by the following equation: where, NL = number of design traffic lanes (Article 3.6): S = girder spacing in feet (6.57S ... 406 Section Properties for Two-Flange Liner Plate .... 203 Maximum Reinforcement of Flexural Members .... 203 Distribution of Flexural Reinforcement .... 203 . The soil shall be defined as nonaggressive if they meet the following criteria: are met: The pH, as determined by AASHTO T 289, is 4.5 to 9 for permanent applications and 3 to 10 for temporary applications, The maximum grain particle size is less than 20 mm (0.75 inches), unless full scale installation damage tests are conducted in accordance with ASTM D 5818, The soil organic content, as determined by AASHTO T 267 for material finer than the 2 mm (No. 10) sieve, is 1% or less, and the design temperature at the wall site, as defined below, is less than 30° C (85° F) for permanent applications and 35° C (95° F)for temporary applications. 411 . (d) 2 in. Allen WEST VIRGINIA, James Sothen WISCONSIN, Stanley W. 601 Pointing .... Net Section 0.46Fu Axial compression, gross section: stiffeners of plate girders. The tolerable level of structural deformation is controlled by the type and span of the superstructure. 669 MATERIALS . 456 Superstructure . A minimum factor of safety of 1.3 shall be used for walls designed for static loads, except the factor of safety shall be 1.5 for walls that support abutments, buildings, critical utilities, or for other installations with a low tolerance for failure. The use of alloys such as alu--minand stainless steel is not recommended. 64 4.4.9 Overall Stability .... However, they are most effective in fill wall applications. For the calculation of bending moments in timber flooring each wheel load shall be distributed as follows. 415 16.6.4.2 General .... Within a band bordered by lines 2" and 14 inches, eyebars shall be spaced such that an 8-inch-square block will not pass through any opening. 66 4.4.11 Structural Design .... 337 BRIDGES .... 284 . LOAD FACTORS. 599 Bubble Masonry .... 198 Shear Stresses .... Division I Iiii . 347 Aluminum Conduits .... 347 Chemical and Mechanical Properties .... 347 Mechanical Properties for Design .... E APP. To achieve E equal to F, at critical sections, the compression-flange bending stress is based on the full flange width b) cannot exceed the limiting value of the reduced nominal capacity, 0.66Fy Design .... C10.48.1.1 (b) and 10.48.1.1 (b) and 10.48.2.1 (b) and 10.48.4.1 (b) and 10.48.4.1 (b). Therefore, the maximum bending strength of noncompact composite sections should be computed according to the revised provisions of Articles 10.50.1.2 or 10.50.2.2, as appropriate. Below, which expresses the maximum bending strength of noncompact composite sections in terms of stress. MPa (Article 4.6.5.3.1) effective vertical stress at midpoint of ith depth interval, MPa (Article 4.6.5.2.1) . i' . 133 ANCHORED WALL DESIGN .... 133 Design Terminology .... Liquid Membrane C ( )Compound Method .... 540 Waterproof Cover Method .... 466 Items with Two or More Columns . 654 Earth .... 654 Cores of Rock .... MAXIMUM PRESSURE q. = K RfBL x AND y FROM CHART FIGURE 4.4.7.1.1.7C Contact Pressure for Footing Loaded Eccentrically About Two Axes Modified after AREA (1980) 53 54 HIGHWAY BRIDGES (a) GEOMETRY CONESIONLESS SOIL FIGURE 4.4.7.1.1.5 (c) COHESIONLESS SOIL FIGURE 4.4.7.1.1.4A Modified Bearing Capacity Factors for Footing on Sloping Ground Modified after Meyerhof (1957) (a) GEOMETRY I 1 b (c) COHESIONLESS NIL FIGURE 4.4.7.1.1.4B Modified Bearing Capacity Factors for Footing Adjacent Sloping Ground Modified after Meyerhof (1957) 4.4.7.1.1.6 DIMSION I-DESIGN 55 4.4.7.1.1.6 Ground Water Ultimate bearing capacity shall be determined using the highest anticipated ground water level at the footing location. 496 General .... 496 Timber Piles .... 539 CURING CONCRETE .... 539 Materials .... 7 or 8w E 16 (b) Detail thickness > 1.0 in. 551 SPLICING OF WELDED WIRE FABRIC .... 552 . b/t 90,000 psi, Y.P. Min. 195 . 10.23.2.2 Minimum Size of Fillet Welds The minimum size of fillet weld shall be as tabulated in Table 10.23.2A. If 4+fnd/o- 52 2 ; 2 (10.42.2.2) If the design of a connection shall be such that the stresses in the adjacent base material do not exceed the values allowed in Article 10.32. If the 3:5 where = 0.9.25 then J = E = 30 8 = 0.84 0.84 0.58 Figure 5.1 Settlement Figure. Special studies may be required to determine the weighted average for a highway tunnel with pedestrian traffic. As an alternative, the required moment of inertia, 1 R u t i f u is used, use = 1.1. ALF. 1 3.2 1 - a 5.5 1.2.5 Beam in Tension .... 6.4.1.3.6 j are (Axial load and the homogeneous soil case assumed in Equation 4.4.7.1.1-1. The maximum resultant force on the eccentrically loaded connection shall not exceed the slip resistance computed from Article 10.32.3.2.1 with Nb taken as 1.0. 10.18.3 Compression Members Compression members such as columns and chords shall have ends in close contact at riveted and bolted splices. 257 Structural Steel .... 257 Steels for Pins, Rollers, and Expansion Rockers .... 257 Tensile strength C10.48.8 Shear The heading of this article is revised to indicate that the provisions apply to stiffened/unstiffened... A maximum factor of safety is used to obtain the allowable load, except for piers and seismic. 4.4.7.1.1.6 ... 4 ... the allowable load, 6, d, and bearing capacity ... all to ... all rock 1.1 ... 4.12 ... GROUND 5.2.1.5.5 ... 2 ... 4 ... 8 ... 11 ... 15 ... 22 ... 36 ... 12 ... 37 ... 52 ... 3 ... 15 ... 30 ... 1.0 ... 3.3 ... 6.5 ... 7.8 ... 7.8 ... 36 ... The allowable stress in the bearing plate shall be 0.85 F ... 2.5 in ... 3.5 in ... 1.5 ... 0.55 Fy ... 4.4.7.2.1 ... 4.4.7.1.1.6-1 ... Figure 5.8.12.1A ... All splices, including ... 4.4.7.1.1.5-3 ... 1.2 ... 10.50.1.1.1 ... and AASHTO M 270 Grade 345W ... of the composite ... The bearing capacity of footings ... 1.5 ... 19 ... 22 ... 27 ... 42 ... 44 ... 60 ... 1.0 ... 4.5 ... 3.0 ... 6.5 ... 9.5 ... 11.5 ... 14.5 ... 20 ... 24 ... 32 ... 42 ... 80 ... 85 ... 120 ... 132 ... 10.38.4.2 ... 7.5 Fy ... (1.5, 3.0, 4.5) ... 10.41.4.9 ... 6.3.1 ... 6.3.2 ... 6.3.3.2 ... 10.18 Splices and Alternative Methods ... 4.5.6.5 ... 4.5.6.1 ... 4.5.6.3 ... 4.5.6.2 Skin friction resistance may be calculated for design purposes as the sum of the friction forces. 10.32.3.2.2 ... 10.32.3.2.3 ... in the direction of the applied load. 4.5.6.7 ... If the potential for downdrag exists, the method of foundation shall be sought ... Settlement of shallow foundations. .252 Fatigue ... Bearing stress ... 10.57.2 ... Overload ... To prevent the use of composite sections ... 10.48.2.1 ... For members subject to bending as a cantilever ... fastener ... 10.19.3 ... 10.19.4 ... 4.5.11 ... 4.5.12 ... 4.5.13 ... 4.5.14 ... 4.5.15 ... 10.32.4.2 ... 10.32.4.3 ... piles ... 3.5 ... 3.8 ... 3.9 ... 3.10 ... 10.16.14 ... 4.12.3.3 ... 4.13.3.3 ... 10.20 ... 10.21 ... 10.22 ... 10.23 ... 10.24 ... 10.25 ... 10.26 ... 10.27 ... 10.28 ... 10.29 ... 10.30 ... 10.31 ... 10.32 ... 10.33 ... 10.34 ... 10.35 ... 10.36 ... 10.37 ... 10.38 ... 10.39 ... 10.40 ... 10.41 ... 10.42 ... 10.43 ... 10.44 ... 10.45 ... 10.46 ... 10.47 ... 10.48 ... 10.49 ... 10.50 ... 10.51 ... 10.52 ... 10.53 ... 10.54 ... 10.55 ... 10.56 ... 10.57 ... 10.58 ... 10.59 ... 10.60 ... 10.61 ... TIMBER STRUCTURES. 1.1 ... GENERAL ... Where necessary ... 1.1.1 ... 1.1.2 ... MEASUREMENT AND PAYMENT ... Where pile load tests are performed at one or more locations. 3.28.1 ... 3.28.2 ... 5.8.12.1 ... 5.8.12.2 ... 10.16.9.4 ... 10.16.10.3 ... Untitled ... Notes ... Flexural Members. 4.4.7.1.1.6-3 ... 3 ... 5.5.5 ... 5.5.6 ... 5.5.7 ... 10.41.4.9 ... 10.41.4.10 ... 4.6.5.3 ... 4.6.5.5.1.1 ... 4.6.5.5.1.2 ... 4.6.5.5.2 ... 4.6.5.6 ... 15 ... 10.19.2.4 ... 10.19.3 ... 1 ... a ... b ... c ... d ... e ... f ... 407 . 318 . See also C17.6.4.7 (1997). 393 Pot Bearing-Critical Dimensions for Clearances . 257 Cast Steel and Ductile Iron .... 257 Malleable Castings .... The slip resistance of the connection shall be computed as specified in Article 10.32.3.2.1. where: F = the maximum elastic flexural stress at the mid-thickness of the controlling flange at the point of splice. Prefabricated modular walls may also use their structural elements to mobilize the dead weight of a portion of the wall backfill through soil arching to provide resistance to lateral loads. 187 SECTION 6-SUBSTRUCTURE AND WALL APPLICATION .... General .... 357 Intersection .... 357 Impact .... It is indicated in this article that the web thickness of transversely stiffened girders is also subject to the limit provided in Article 10.49.2, which applies to singly symmetric transversely stiffened sections where DcexceedS DI2. The current language infers that the entire beam must be compact. 473 Splices . Strength Limit States . 66 General .... Excavations Within Channels .... 478 FoundationsonRock .... 3.25.1.4 The determination of the minimum size and spacing required of the wood blocks exposed to transfer the load shall be as specified in the following equation: where, *The terms interconnected and non-interconnected refer to the joints between the individual nail laminated or glued laminated panels. 410 16.4.3 Standard Installations .... 5.8.9.3.2 Tip Resistance . 5.8.8.3 Corrosion Issues for MSE Facing Design Steel to steel contact between the soil reinforcement connections and the concrete facing shall be prevented so that contact between dissimilar metals (e.g., bare facing reinforcement steel and galvanized soil reinforcement steel) does not occur. Pi Plates .... 284 PinsandPinNuts .... 285 UPSET ENDS .... 10.16.4.2 Handling Stresses Reinforcement cages shall be designed to resist handling and placement stresses. .... 478 Pile Bent .... 478 MEASUREMENT AND PAYMENT .... 479 Payment .... The maximum vertical spacing between reinforcement layers shall be limited to twice the width, W, (see Figure 5.8.7.2A) of the proposed segmental concrete facing unit or 0.8 meter (31 inches). 8.1 DIVISION I-DESIGN whichever is less, and the maximum facing height above the uppermost reinforcement layer and the maximum depth of facing below the bottom reinforcement layer should be limited to the width, W, (see Figure 5.8.7.2A), of the segmental facing block used. Clearing of brush and trees along embankments is in the vicinity of bridge openings should be avoided to prevent high flow velocities and possible scour. F, on continued material in long-slotted holes perpendicular to the applied loading for 'lkid d = F LU 5 o--F.U. AASHTO M 164 (ASTM A 325) and AASHTO M 253 (ASTM A 490) high-strength bolts are workable in three types, designated a t y p l , 2, or 3. 49 Geotechnical Design to Soil .... 3.253 Longitudinal Girder Limited Table 3.25.3.1 Shear Moment Diameter Capacity of h I b/O MD in. Sole Plates and Masonry Plates . New Jersey, Negative Moment Reinforcement. This type of wall requires little excavation behind the wall and is most effective in cut applications. In service load design, the combined dead, live, and impact stresses for this loading shall be not greater than 150% of the allowable stresses given in Table 10.32.1A. 76 Handling Stresses . The current article does not include provisions for the design of compact composite hybrid sections. "FIGURE 5.8.1A MSE Wall Element Dimensions Needed for Design at the wall base. The maximum shear is for a wheel position assumed to be 15 inches or less from the center line of the Thus, 3R t = -(- whichever is greater 2F" (3 - 26) where, M, = primary bending moment in inch-pounds per inch; R, = primary shear in pounds per inch; n = denotes direction perpendicular to longitudinal stringers; P = design wheel load in pounds; s = effective deck span in inches. For t - d-b,-17 - &l-; H1 Zone of maximum stress r = potential Failure surf ace I N reinforcement. Note that since it is assumed that 4 = p, and that p is assumed to always be zero for vertical walls. for a vertical wall, the Coulomb equation simplifies mathematically to the simplest form of the Rankine equation: If the wall face is battered, the following simplified form of the Coulomb equation can be used: with variables as defined in Figure 5.2A. 5.2.1 Selection of Wall Type Selection of wall type is based on an assessment of the magnitude and direction of loading, depth to suitable foundation support, potential for earthquake loading, presence of deleterious environmental factors, proximity of physical constraints, wall site cross-sectionalgeometry, tolerable and differential settlement, facing appearance, and ease and cost of construction. 4.13.3.3.8 Cohesionless Soil Evaluation of group capacity of shafts in cohesionless soil shall consider the spacing between adjacent shafts. Procedures for measuring movements. blt = 14 295 10.34.2.2.3 Where the calculated compressive bending stress equals 0.55 Fy, the b/t ratios for the various grades of steel shall not exceed the following: 36,000 psi, Y.P. Min. The intent of this provision is to control the crack size in the deck. The maximum bending strength of these sections is now expressed in terms of the maximum strength F, of the compression and tension flanges, expressed in terms of stress rather than moment, in revised Articles 10.50.1.2 and 10.50.2.2 (see discussion of these revised articles) 10.34.2.2.3. The moment-shear interaction relationship for these sections is revised accordingly. Inextensible reinforcements reach their peak strength at strains lower than the strain required for the soil to reach its peak strength. 284 General . 11, PennDOT Office of Research and Special Studies, Fritz Engineering Laboratory Report No. 519-2, Lehigh University, May 1995. It is specified that the sum of the factored noncomposite and composite dead-load shears be used in checking for shear buckling of the web during construc- C10.57.2 Composite Sections This revised article limits the maximum overload flange stresses in composite noncompact sections (versus girders) to 0.95FYThe hybrid factor R is eliminated because web yielding, should it occur, is limited at overload. Refer to Figure 5.5.2A for procedures to determine the magnitude and location of the earth pressure resultant force for gravity and semigravity retaining walls subjected to active earth pressures. 377 Modulus of Elasticity .... 377 Bending .... Alabama also underlined information shall consider the location of suitable soil or rock strata, the presence of buried utilities or other geometric constraints, and constructability of the anchor drill holes. .500 Wet Construction Method .... 500 Temporary Casing Construction Method . For heavy traffic roads, roadway widths greater than the above minima are recommended. 4. Division I-A .... Note: Article 10.58.2.2refers back toASDArticle10.38.5.1 for the computation of fatigue shear ranges. 67 Lateral Forces .... 534 Cleanup .... 404 Joint Strength .... 404 Minimum Stiffness for Installation .... 608 . 685 CONSTRUCTION METHODS . For completeness, reference to Articles 10.50

(Composite Sections), 10.51 (Composite Box Girders), and 10.53 (Hybrid Girders) is added for the computation of the maximum bending strength of transversely stiffened girders. 230 Bottom Flange ..... The difference in width between the top and bottom bearing surfaces shall not exceed twice the distance between them. Spans greater than 150 feet; 4 bolts, 1%inches in diameter, set 15 inches in the masonry. 283 Maximum Spacing of Sealing and Stitch Fasteners .....283 Sealing Fasteners ..... 10.15.3 Camber To compensate for possible loss of camber of heatcurved girders in service as residual stresses dissipate, the amount of camber in inches, A at any section along the length L of the girder shall be equal to: 1,000- R 850 EYO AR = 0 for radii greater than 1,000 AR = 10.15 HEAT-CURVED ROLLED BEAMS AND WELDED PLATE GIRDERS 14bD 0.02 L'F, (where AD, is the camber in inches at any point along the length L calculated by usual procedures to compensate for deflection due to dead loads or any other specified loads; AMis the maximum value of ADLin inches within the length L; E is the modulus of elasticity in ksi; F, is the specified minimum yield point in h i of the girder flange; Yois the distance from the neutral axis to the extreme outer fiber in inches (maximum distance for nonsyrnmetrical sections); R is the radius of curvature in feet; and L is the span length for simple spans or for continuous spans, the distance between a simple end support and the dead load contraflexure point, or the distance between points of dead load contraflexure. 215 Maximum and Minimum Longitudinal Reinforcement . 1999l2000 COMMENTARY C10.21 LATERAL BRACING The word preferably has ben added to the fist sentence because there may be special instances where it may be desirable to include lateral bracing in the interior bays as well. 539 Pedestrian Walkway Surface Finish .....539 Troweled and Brushed Finish . Guidelines for how to determine & and RFDfrom product specific data are provided in FHWA Publication No. FHWA SA-96-071 "Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelinesw-Appendix B, and in FHWA Publication No. FHWA SA-96-072 "Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes."For wall applications which are defined as not having severe consequences should poor performance or failure occur, having nonaggressive soil conditions, and if the geosynthetic product meets the minimum requirements listed in Table 5.8.6.1.2A, the long-term connection strength may be determined using a default reduction factor for RF,as provided in Table 5.8.7.2A for the ultimate limit state in lieu of product specific test results. 28 28 Force of Stream Current on Piers ..... .530 . Any material or combination of materials listed in Article 2.7 may be used in any cog~guration. Values of c, may be estimated from the results of laboratory consolidation testing of undisturbed soil samples or from in-situ measurements using devices such as a piezoprobe or piezocone. 'This shall apply to pins used primarily in axially loaded members, such as truss members and cable adjusting links. 2.7.1.3.4 The attachment of each rail required in a traffic or combination railing shall be designed to resist a vertical load equal to one-fourth of the transverse design 2.7.1.3.6 The transverse force on concrete parapet and barrier walls shall be spread over a longitudinal length of 5 feet. End floor beams for truss spans preferably shall be designed to permit the use of jacks for lifting the superstructure. Buoyant unit weights shall be used for soil below the groundwater level. .....525 Cements .....4.3.5 Scour The probable depth of scour shall be determined by subsurface exploration and hydraulic studies. Equation (10-118a) is added to this article to better accommodate composite non-compact sections. 78 4.5.21.2 Limitations on Untreated Timber Pile Use . Support Systems 550 Precast Concrete Blocks .....550 WireBarSupports ..... m a -10 C eOLSlON OF FOU(IWTION SOIL. Piles Extending Above Ground Surface . For a horizontal, static ground water table, the total hydrostatic water pressure should be determined using the following relationship: If the ground water levels differ on opposite sides of a wall, the effects of seepage forces on wall stability or piping potential shall be considered. Footings on piles may be located above the lowest anticipated scour level provided the piles are designed for this condition.Assume that only one-half of the maximum anticipated scour has occurred when designing for earthquake loading. 26 WIND LOADS . 335 Slab Reinforcement .....335 Shear Connectors ..... For a horizontal static ground water table, the total hydrostatic water pressure shall be determined using Equation 5.5.3-1. Jensen; and Bulletin 346, "Highway Slab Bridges with Curbs; Laboratory Tests and Proposed Design Method." 36 HIGHWAY BRIDGES B, unless more exact methods are used considering tire contact area. (To be used when curb projects more than 9" from the traffic face of railing.) COMBINATION TRAFFIC AND PEDESTRIAN RAILING (To be used where there is no curb or curb projects 9"or less from traffic face of railing.) TRAFFIC RAILING FIGURE 2.7.4B Traffic Railing 2.7.4.3 15 DIVISION I-DESIGN (e) the distance between lateral supports in inches of W or I sections shall not exceed (c) The D/t ratio of we& shall not exceed D 1 (3-13) where, W = overall width of bridge measured perpendicular to the longitudinal girders in feet; "'For Eootnotesa through e, see Table 3.23.1. flf S exceeds denominator, the load on the beam shall be the reaction of the wheels loads assuming the flooring between beams to act as a simple beam. The performance factor for the ultimate tip resistance of piles bearing on rock shall be as provided in Table 4.10.6-2. ASTM Designation Grade or Class - A 108 Grades 1016 1030 incl. Painting . Lumber and Timber (Solid Sawn or Glued Laminated) . 517 Drainage Blankets ..... .500 ConstructionSequence ..... Number of Cycles Not more than 20,000 From 20,000 to 500,000 More than 500,000 AASHTO M 164 (ASTM A 325) AASHTO M 253 (ASTM A 490) 38 35.5 27.5 47 44.0 34.0 10.32.4 Pins, Rollers, and Expansion Rockers 10.32.4.1 The effective bearing area of a pin shall be its diameter multiplied by the thickness of the material on 10.32.4.1 DIVISION I-DESIGN 293 TABLE 10.32.4.38 Allowable Stresses-Steel Bars and Steel Forgings AASHTO Designation with Size Limitations - M 169 4 in. 546 PlacingandCuring .....547 APPLICATION OF LOADS .....547 General . Thus, the revised article also requires that fdlbe taken as the factored non-composite dead load compression-flange stress divided by Rb, but not to exceed F,. C10.38.5.1.2 Ultimate Strength An upper limit on the ultimate strength of a stud shear connector (in pounds) is specified. 417 16.4.6.4 Process and Material Factors . Load tests shall be conducted using shafts constructed in a manner and of dimensions and materials identical to those planned for the production shafts. S. 315 10.41.4.8.2 Wearingsurface ..... Nongravity cantilevered walls may be used for the same applications as rigid gravity and semi-gravity walls, as well as temporary or permanent support of earth slopes, excavations, or unstable soil and rock masses. 177 Overturning ..... 11.6.7 Misfits . Table 5.5.2B may be used for general guidance in selecting coefficients of sliding friction between the wall base and foundation soil or rock. 82 4.6.5.1.4 Tip Resistance in Cohesionless Soil . At other locations throughout this article, the word 'members' is changed to 'sections' where the use of the word 'sections' is felt to be more appropriate. 517 DRAINAGE ..... .354 C , Adjustment Coefficient Values for Number of Wheels Per Axle .....356 P, Crown Moment Proportioning Values ..... The allowable stresses shall be as set forthinArticles 8.15.2,8.16.1, and 10.32. The total thickness of all cover plates should not be greater than 2% times the flange thickness. 401 Other Bearing Systems ..... 309 Figure 10.39.4.3B Spacing and Size of Transverse Stiffeners (for Flange Stiffened Longitudinally and Transversely) .....310 Untitled .....313 Figure 10.40.2.1A Figure 10.40.2.1B Untitled .....313 Figure 10.50A Plastic Stress Distribution .....323 Article C10.50.1.2.1 .....C.130 Figure 1 SECTION 1243OIL-CORRUGATEDMETAL STRUCTURE INTERACTION SYSTEMS Figure 12.7.1A Figure 12.7.4A Figure 12.7.4B Figure 12.7.5A Figure 12.8.2A Standard Terminology of Structural Plate Shapes Including Long-Span Structures .....349 m i c a 1 Structural Backfill Envelope and Zone 351 of Structure Influence ..... In developing the design earth pressure for a particular wall section, consideration shall be given to wall displacements that may affect adjacent structures or underground utilities. .230 -Top Flange . 611 Stringers ..... Alternatively, noncorrosive reinforcing elements can be considered. .I65 Distribution of Stress from Concentrated Vertical Load P, for Internal and External Stability Calculations .... 307 10.38.6 Deflection . T or Rev B 21 Base metal at net section of high-strength bolted bearing-type connections. 72 Single Pile ..... Drawings showing the procedures and materials to be used to construct the load test apparatus. 129 .. 612 Glue Laminated Panel Decks ..... -797 As referenced in Section 4.12.3.3.7b and 4.13.2, the following figures have been reprinted from the 1993 Commentary of the 1993 Interims to the Standard Specificationsfor Highway Bridges: Figure C4.12.3.7.2-1 Uplii of Group of Closely-Spaced Pies in Cohesionless Soils ..... Permanent walls shall be designed to retain an aesthetically pleasing appearance, and be essentially maintenance free throughout their design service life. -78 4.6.1.1 Application . 194 SLAB AND WEB THICKNESS . Sufficient research has not yet been conducted on composite sections of variable-depth members with or without longitudinal web stiffeners, composite sections of constantdepth members with longitudinalweb stiffeners, or on composite sections of variable- or constant-depthmembers with C-132 HIGHWAY BRIDGES holes in the tension flange to determine if these sections can achieve the full plastic moment capacity in negative bending. 10.18.2.1.6 Flange and web splices in areas of stress reversal shall be checked for both positive and negative flexure. Note: For celatively thick facing elements (8.g.. .290 Tables CONTENTS Table 10.32.3B Table 10.32.3C Table 10.32.4.3A Table 10.32.5.1A Table 10.36A Table 10.48.1.2A Table 10.48.2.1A Table 10.56A Table 10.57A Allowable Stresses on High-Strength Bolts or Connected Material (ksi) .....290 Nominal Slip Resistance for Slip-Critical Connections (Slip Resistance per Unit of Bolt Area. 84 4.6.5.2.4.3 Group in Strong Soil Overlying Weaker Soil . 331 Slip-Critical Joints ..... 500 Dry Construction Method . Finally, the local buckling capacity of a transverse stiffener is combined with the area requirement for the stiffener in a new Equation (10-32a). M, and H, may be computed as follows: 10.18.2.3.8 DIVISION I-DESIGN where: FCf= design stress at the point of splice for the controlling flange defined in Article 10.18.2.2.3 (positive for tension; negative for compression) R = reduction factor for hybrid girders specified in Article 10.40.2.1. R shall be taken equal to 1.0 when Fcfis less than or equal to the allowable flexural stress for the web steel. 434 Profile Wall PVC Pipes ..... In every case, hole excavation, concrete placement, and all other aspects shall be performed in conformance with the provisions of this specification and Division II. 505 - --- -- -- - - - - ? 659 Mixing of Materials ..... of Carboxyl End Group Content of 30 GRI Test Method GG7 Hydrolysis Resistance Survivability Weight per Unit Area (ASTM D 5261) Min.270 g/m2 Maximum of 0% % Post-Consumer Recycled Certification of Materials Used Material by Weight *Polymers not meeting these requirements may be used if product specific test results obtained and analyzed in accordance with FHWAPublication No. FHWASA-96-071 "MechanicallyStabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines"-Appendix B, and in FHWA Publication No. FHWA SA-96-072 "Corrosion/Degradationof Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes" are provided. 369 General .....-369 Notching ..... The local practice or traditional method used in similar soillrock deposits. Lower Side Material . Maddipudi. 427 PRECAST REINFORCED CONCRETE THREE-SIDED STRUCTURES ..... The revised Equation (10-34) is equivalent to the LFD requirement. Assumed f o r overturning end slldzng reslstanee comps. 497 Timber, Steel, and Concrete Piles .....497 Piles Furnished ..... (c) 6 in.-> 'Ransition radius r 2 in. The bottom strut of the transverse interior bracing in the box can be considered to act as a transverse stiffener for this purpose if the strut satisfies the appropriate stiffness requirements. Epoxy coating for corrosion protection of panel reinforcement where salt spray is anticipated is recommended. 43 Soil, Rock, and Other Problem Conditions .....43 SUBSURFACE EXPLORATION AND TESTING PROGRAMS .....43 General Requirements ..... 3) Replacing Mwuwith Mwoand Hwuwith Hwo computed from the previous formulas only using the actual stresses at the midthickness of the flanges due to D + PL(L+I) in place of the design stresses. 11.5.3.1 General . 613 PAYMENT . .496 ..... 225 General .....225 . .626 Copper Alloy Plates .....626 Special Fabrication Requirements for Disc Bearings . 222 SPLICES OF REINFORCEMENT .....222 LapSplices .....222 Welded Splices and Mechanical Connections. C10.48.8 Shear Editorial revisions are indicated in this article to be consistent with the editorial revisions to previous articles discussed above. Shallow keying or benching of large footing areas shall be avoided where blasting is required for rock removal. Unfactored dead and live loads shall be used to determine the FS against sliding and overturning. Both the noncomposite and composite dead-load shears are critical in checking the stability of the web during construction. 312 10.39.8 HYBRID GIRDERS ..... .570 Storage of Materials ..... Pos. 10.16.10.5 Lacing bars may be shapes or flat bars. Compression in splice material, gross section Compression in extreme fibers of rolled shapes, girders, and built-up sections subject to bending. 555 PLACEMENT OF DUCTS, STEEL, AND ANCHORAGE HARDWARE ..... The loads expected to act on the production foundation (compressive and/or uplift, dead and/or live), and the soil conditions predominant in the region of concern. where: V, = design shear in the web at the point of splice defined in Article 10.18.2.3.2 e = distance from the centerline of the splice to the centroid of the connection on the side of the joint under consideration 10.18.2.3.4 As arninimum, in the case of the strength design method, web splice plates and their connections shall be proportioned for a design moment at the point of splice, M, representing the portion of the flexural moment that is assumed to be resisted by the web. Frank, "The Ultimate Strength of Symmetric Beam Bolted Splices," AISC Engineering Journal, 3rd Quarter, 1998, and 'The Ultimate Strength of Unsymmetric Beam Bolted Splices,"AISC Engineering J o u m l , 2nd Quader, 2001. q FACTOR OF SAFETY AGAINST OVERTURNING (MOMENTS ABOUT POINT 011 FSor - - Z Moments Reslrtlnq (Mr) Z Moments Overturning (Me) - F V, (L/2) (HI31 + 5 (HIZ~ 2*0 FACTOR OF SAFETY AGAINST SLIOINGI - += F r i c t ~ o nAngle where q = o f Reinforced B s c k f l l l o r Foundet~on. Up to 4 in. Multipliers for other reinforcement types can be developed as needed through analysis of measurements of reinforcementload and strain in full scale structures. 1.5 ROADWAY DRAINAGE The transverse drainage of the roadway should be provided by a suitable crown in the roadway surface and longitudinal drainage by camber or gradient. 15C0of the intact rock. If methods other than those given in Tables 4.10.6-1, 4.10.6-2, and 4.10.6-3 are used to estimate the soil capacity, the performance factors chosen shall provide the same reliability as those given in these tables. Other anchor types and installation procedures could provide other estimated ultimate anchor capacities. Hh= 2 C(W, where: - - Gu 0.5Hu ten corn 1b l/tan(W + ib % %= &, = Segmental fecrng block u n i t hrrght (m) frgmmn+ol f ecing block unrt wrdth. 651 .. Sheet Pile Walls ..... Application .....595 Painting Treated Timber .....595 Payment . and D ..... 435 Poly (Vinyl Chloride) (PVC) ..... Society, 1985) Skin friction and end bearing 0.45 0.35 0.50 Clay 0.45 0.55 0.80 0.70 0.65 Uplift capacity of single piles a-method @-method bmethod SPT-method CPT-method Load Test 0.60 0.40 0.45 0.35 0.45 0.80 Group uplift capacity Sand Clay 0.55 0.55 Block failure ysis of soil and groundwater samples should be considered. See Part D-Strength Design Method-Load Factor Design for an alternate design procedure. 357 Notations ..... Such methods are based on soil and rock parameters measured directly or inferred from the results of in situ and/or laboratory test. .415 Bedding Factor ..... .212 Distribution of Flexural Reinforcement . 520 Crib Walls and Cellular Walls . 193 MODULUS OF ELASTICITY AND POISSON'S RATIO .....193 SPAN LENGTH ..... C10.51 COMPOSITE BOX GIRDERS C10.51.5 Compression Flanges The equation for the buckling coefficient for a longitudinally stiffened bottom flange plate in the current specifications assumes that the plate and stiffeners are infinitely long and ignores the effect of any transverse bracing or stiffening. 4 ENERAL REQUIREMENTS AND MATERIALS APPLICATION ..... 91 General . 10.56.3.1 All rigid frame connections, the rigidity of which is essential to the continuity assumed as the basis of design, shall be capable of resisting the moments, shears, and axial loads to which they are subjected by maximum loads. Rigid frames shall be designed for anticipated differential settlements based on the results of special analysis. .99 Presumptive Bearing Pressures (tsf) for Foundations on Rock (after Putnam, 1981) ..... T or Rev D 21 Base metal at the net section of eyebar head, or pin plate Base metal in the shank of eyeban, or through the gross section of pin plates with: (a) rolled or smoothly ground surfaces (b) flame-cut edges T E 23,24 T T A B 23,24 D E -. .489 Timber Piles . The total inertial force PI per unit width of structure shall be considered equal to the weight of the active zone times the maximum wall acceleration coefficient A,. 379 General ..... SECTION 21WATERPROOFING GENERAL ..... 196 SERVICE LOAD DESIGN METHOD (AllowableStress Design) ....197 General Requirements .....197 Allowable Stresses ..... 10.19.1.2 Connections shall be made symmetrical about the axis of the members insofar as practicable. 4.4.1.2 Footings Supporting Non-Rectangular Columns or Piers .....45 FootingsinFill .....45 4.4.1.3 4.4.1.4 Footings in Sloped Portions of Embankments .....45 45 4.4.1.5 Distribution of Bearing Pressure ..... AISC then introduced a Cb moment-gradient correction factor for handling lateraltorsional buckling of beams, which happens to approximately equal the inverse of the C, factor presented by Austin with the lower limit of 0.4. Zandonini (Reference 9) subsequently pointed out that the C, factor could indeed be used effectively to determine the second-order bending strength of beam columns if the 0.4 limit was eliminated. 596 Measurement and Payment ..... l j p c 3 shaU be required on the plans when k g ~ n r n t cA d A S M~no ~ r a d eMW (ASTUA 709 ~ r a d SOW e). C-130 C10.50.1 HIGHWA.Y BRIDGES Positive Moment Sections The words 'of Composite Beams and Girders' are considered redundant and are removed form the heading for this article for consistency with the revision to the heading for Article 10.50. 217 HOOKS AND BENDS .....217 . E HIGHWAY BRIDGES APP-E 743 Section 9 PRESTRESSED CONCRETE NOTATIONS of non-prestressed tension reinforcement, d (Articles 9.7 and 9.19) = area of compression reinforcement, d (Article 9.19) = area of prestressing steel, d (Article 9.17) = steel area required to develop the compressive strength of the overhanging portions of the flange, mm2 (Article 9.17) = steel area required to develop the compressive strength of the web of a flanged section, d (Articles 9.17-9.19) = area of web reinforcement, d (Article 9.20) = width of flange of flanged member or width of rectangular member, mm = width of cross section at the contact surface Wing investigated for horizontal shear, mm (Article 9.20) = width of a web of a flanged member, mm (Article 9.20.2.2) = loss of prestress due to creep of concrete, MPa (Article 9.16) = loss of prestress due to relaxation of prestressing steel. Dl100 10.34.3.2 Girders Stiffened Longitudinally 10.34.3.2.1 The web plate thickness of plate girders equipped with longitudinal stiffeners shall not be less than that determined by the formula d for S20.4 Dc k=5.17 but in no case shall the thickness be less than Dl340. Elements of the connection which are embedded in the facing element shall be designed with adequate bond length and bearing area in the concrete to resist the connection forces. 623 General .....623 Special Fabrication Requirements for Metal Rocker and Roller Bearings ..... .282 Allowable Stresses-Structural Steel (In pounds per square inch) ..... 522 MEASUREMENTAND PAYMENT ..... ." I1 where SF is equal to the allowable stress range for Category C given in Table 10.3.1A.This assumes no penetration at the weld root. Precast Reinforced Concrete Circular Arch and Elliptical Pipe . 402 CORROSION PROTECTION ..... 457 .. American Concrete Institute, Publication SP-3, "Reinforced Concrete Design Handbook, Working Stress Method," 1965. 5.5.6.1 Base or Footing Slabs The rear projection or heel of base slabs shall be designed to support the entire weight of the superimposed materials, unless a more exact method is used. Size of Pins . The stress in the longitudinal stiffener is controlled directly by the provisions of Article 10.34.5.3, and therefore, need not be indirectly controlled through the width-to-thickness requirement, as is currently the case. .619 18.4.3.3 Lubricants ..... 163 FacingISoil Reinforcement Connection Design for Seismic Loads ..... The polymer material reuirements provided in Table 5.8.6.1.2A shall therefore be met if detailed product specific data as described in FHWA Publication No. FHWA SA-96-071 "Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines '-Appendix B, and in FHWA Publication No. FHWA SA-96-072 "Corrosion/Degrada9 5.8.6.1.2 tion of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes" is not obtained. Hydrologic Analysis ..... TABLE 4.4.7.2.2B Elastic Shape and Rigidity Factors EPRI (1983) LA Circular 1 2 3 5 10 Bz Bz Hexible (average) Rigid 1.04 1.06 1.09 1.13 1.22 1.41 1.13 1.08 1.10 1.15 1.24 1.41 4% 60 HIGHWAY BRIDGES 4.4.7.2.3 the following when laboratory test results are expressed in terms of void ratio (e): For initial overconsolidated soils (i.e., opt > uot): For initial normally consolidated soils (i.e., u p t = uot): - Vertical affective stress, u'(lop scale) If laboratory test results are expressed in terms of vertical strain (E,), consolidation settlement may be estimated using the following: For initial overconsolidated soils (i.e., up' > a,'): FIGURE 4.4.7.2.3A Typical Consolidation Compression Curve for Overconsolidated SoilVoid Ratio Versus Vertical Effective Stress EPRI (1983) For initial normally consolidated soils (i.e., up' = uof): Refer to Figures 4.4.7.2.3A and 4.4.7.2.3B for the definition of terms used in the equations. 81 4.6.5.1.2 Side Resistance in Cohesionless Soil ..... 11.5.6.2 Bolted Parts ..... 286 Floor Beams .....286 Cross Frames ..... 587 Description ..... 540 Waterproof Sheet Materials ..... The use of these semi-empirical procedures shall take local experience into consideration. C11.4.11 Annealing and Stress Relieving Requirements for Grade HPS7OW steel have been added. .425 16.4.5.1 16.4.5.1.1 16.4.5.2 16.4.5.2.1 16.4.5.2.2 16.4.5.2.3 16.4.5.2.4 16.4.6 Division I Division I CONTENTS ..... OP b. 202 Definition of Wall Slenderness Ratio .....206 Untitled ..... 2. AASHTO M 270 Grade HPS70W (ASTM A 709 Grade HPS70W) steel has been added to the list of steels that have the demonstrated ability to reach the plastic moment capacity M,. .288 Allowable Stresses for Low-Carbon Steel Bolts and Power Driven Rivets (in psi) ....568 Alternative Fasteners .....568 Load Indicator Devices .....568 Welded Stud Shear Connectors ..... R= 10.15.1 Scope This section pertains to rolled beams and welded I-section plate girders heat-curved to obtain a horizontal curvature. 527 527 PROPORTIONING OF CONCRETE ..... 4.12.2 Notations a, = pile perimeter A, = area of pile tip A, = surface area of shaft of pile CPT = cone penetration test d = dimensionless depth factor for estimating tip capacity of piles in rock D = pile width or diameter D' = effective depth of pile group Db = depth of embedment of pile into a bearing stratum D, = diameter of socket ex = eccentricity of load in the x-direction e, = eccentricity of load in the y-direction Ep = Young's modulus of a pile E, f, = soil modulus H = distance between = sleeve friction measured from a CPT at point con- sidered pile tip and a weaker underlying soil layer H, = depth of embedment of pile socketed into rock = influence factor for the effective group embedI ment = moment of inertia of a pile I, K = coefficient of lateral earth pressure K, = correction factor for sleeve friction in clay K, = correction factor for sleeve friction in sand I&, = dimensionless bearing capacity coefficient I+ = depth to point considered when measuring sleeve friction nh = rate of increase of soil modulus with depth N = Standard Penetration Test (SPT) blow count N = average uncorrected SPT blow count along pile shaft 102 N,,, HIGHWAY BRIDGES = average SPT-N value corrected for effect of overburden N,,,, = number of piles in a pile group OCR = overconsolidation ratio PD = unfactored dead load P, = factored total axial load acting on a pile group P,, = factored axial load acting on a pile in a pile group; the pile has coordinates (X,Y) with respect to the centroidal origin in the pile group PI = plasticity index = net foundation pressure q q, = static cone resistance ql = limiting tip resistance qo = limiting tip resistance in lower stratum q, = ultimate unit tip resistance q, = ultimate unit side resistance q, = average uniaxial compressive strength of rock cores quit = ultimate bearing capacity Q, = ultimate load carried by tip of pile Q, = ultimate load carried by shaft of pile Q,, = ultimate uplift resistance of a pile group or a group of drilled shafts Q,,, = ultimate bearing capacity R = characteristic length of soil-pile system in cohesive soils sd = spacing of discontinuities = average spacing of piles S S, = undrained shear strength SPT = Standard Penetration Test S, = average undrained shear strength along pile shaft t, = width of discontinuities T = characteristic length of soil-pile system in cohesionless soils W, = weight of block of soil, piles and pile cap = distance of the centroid of the pile from the cenx troid of the pile cap in the x-direction X = width of smallest dimension of pile group = distance of the centroid of the pile hornthe troid of the pile cap in the y-direction group or &up of drilled shafts Y = length of = total embedded pile length Z = adhesion factor applied to S, a p = coefficient relating the vertical effective stress and the unit skin friction of a pile or drilled shaft = effective unit weight of soil y' = angle of shearing resistance between soil and pile 6 = empirical coefficient relating the passive lateral h earth pressure and the unit skin friction of a pile = pile group efficiency factor q p = settlement pml = tolerable settlement u; = horizontal effective stress u: u,, 0, 0, 0 0, 0, 0, 4.12.2 = vertical effective stress = average shear stress along side of pile = performance factor = performance factor for the bearing capacity of a pile group failing as a unit consisting of the piles and the block of soil contained within the piles = performance factor for the total ultimate bearing capacity of a pile = performance factor for the ultimate shaft capacity of a pile = performance factor for the ultimate tip capacity of a pile = Performance factor for the uplift capacity of a single pile = performance factor for the uplift capacity of pile grOUPs 4.12.3 Selection of Design Pile Capacity Piles shall be designed to have adequate bearing and structural capacity, under tolerable settlements and tolerable lateral displacements. When conventional cast-in-place composite decks are used, the lateral bracing requirement of Article 10.48.2.1(c) and the compression-flange slenderness requirement of Article 10.48.2.1(a) need not be checked. (Articles 8.16.4.1.2 and 8.16.4.2.1) = area of shear reinforcement within a distance s, mm2 (Article 8.19.1.2) = area of shear-friction reinforcement, mm2 (Article 8.15.5.4.3) = area of an individual wire to be developed or spliced, mm2 (Articles 8.30.1.2 and 8.30.2) = loaded area, mm2 (Articles 8.15.2.1.3 and 8.16.7.2) = maximum area of the portion of the supporting surface that is geometrically similar to and concentric with the loaded area, mm? .55 Figure 4.4.7.1.1.7A Typical Two-Layer Soil Profiles ..... Batching ..... Dimensions of the Locg Zone ..... 562 Equipment ..... 10.23.4 Fillet Weld End Returns Fillet welds which support a tensile force that is not parallel to the axis of the weld, or which are proportioned to withstand repeated stress, shall not terminate at comers of parts or members but shall be returned continuously, full size, around the comer for a length equal to twice the weld size where such return can be made in the same plane. 306 10.38.5.1.3 Additional Connectors to Develop Slab Stresses ..... = 0.15 for all other steels and when holes are less than or equal to 1 % inch in diameter. 300 10.35.1 Perforated Cover Plates and Lacing Bars ..... 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. 272 .. .650 . When floodplain erosion may undermine the reinforced fill zone or facing column, or where the depth of scour cannot be reliably determined. 4.11.4.2.4 Presumptive Bearing Values For simple structures on good quality rock masses, values of presumptive bearing pressure given in Table 4.11.4.2.4-1 may be used for preliminary design. 161 Internal Stability ..... adhesion factor as a function over ith depth interval, nondim. 195 Composite Flexural Members . 247 PRETENSIONED ANCHORAGE ZONES .....247 CONCRETE STRENGTH AT STRESS TRANSFER .....247 DECK PANELS .....247 PART D-DETAILING 9.25 9.26 FLANGE REINFORCEMENT .....247 COVER AND SPACING OF STEEL ..... 503 Integrity Testing .....526 . 345 Design .....345 Flexibility Factor .....346 Minimum Cover .....346 SectionProperties ..... 4.10.2 Semceability Limit States Service limit states for foundation design shall include: -settlements, and -lateral displacements. 83 4.6.5.2.4.2 Cohesionless Soil . the standard practice of the commission for the highway construction, except that the superelevation shall not exceed 0.10 foot per foot width of roadway. 86 4.6.5.5.1.3 Mixed Soil Profile . The tolerable level of wall lateral and vertical deformations is controlled by the type and location of the wall structure and surrounding facilities. 645 Wire-Enclosed Riprap (Gabions) .....645 Filter Fabric ..... 400 Materials .....400 Overall Geometric Requirements ..... .552 MEASUREMENT .....552 PAYMENT .....552 SECTION 10-PRESTRESSING 10.1 10.1.1 10.1.2 10.2 10.2.1 GENERAL .....553 Description .....553 Details of Design ..... The compression-flange thickness, t, preferably shall not be less than 1.5 times the web thickness. .620 18.4.8.1 Low-friction Material ..... 409 16.4.2 Materials ..... EMBEDMENT IN SOIL 129 b. For yielding walls, lateral earth pressures shall be computed assuming active stress conditions and wedge theory using a planar surface of sliding defined by Coulomb Theory. 257 General ..... B. 382 Tension Perpendicular to Grain ..... 418 16.4.6.6.2 Minimum Reinforcement ..... 4 SiteData . 531 Cold Weather Protection ..... Shear resisting devices between the facing blocks and backfill reinforcement such as shear keys, pins, etc. 568 Materials .....568 Test Methods ..... The reinforcement steel in the outer quarters of both short and long spans may be reduced by 50%. The yield stress F, is replaced with the factored bending stress in the compression flange fb in determining whether or not the load-shedding factor Rbisequal to 1.0 for a longitudinally stiffened girder. Dean Carlson, Kansas Executive Director: John Horsley, Washington, D.C. HIGHWAY SUBCOMMITTEE ON BRIDGES AND STRUCTURES 2002 TOM LULAY, Oregon, Chaimzan SANDRA LARSON, Vice Chaimzan JAMES D. :;. The recommended proportions are based on a study by Zureick and Shih (Reference 6) on doubly symmetric tangent girders, which clearly showed that the web buckling capacity was dramatically reduced when the compression flange buckled prior to the web. P06. A height of HZ shall be used to calculate PAEin this case. 202 Flexure . The tire contact area needed for exact methods is given in Article 3.30. ,431 Notations .....431 Loads .....431 . All values used in design shall be confirmed by field andlor laboratory testing. 571 Hot Bending ..... T., T. .33 Distribution of Wheel Loads in Transverse Beams . 264 Figure C10.18.2.3.4 Positive Flexure Case .....C.101 Figure C10.18.2.3.4 Negative Flexure Curve .....C.101 Figure 10.18.5A Splice Details .....278 Web Thickness Versus Girder Depth for Noncomposite Figure 10.34.3.1A Symmetrical Sections .....296 Figure 10.39.4.3A Longitudinal Stiffeners-Box Girder Compression Flange ..... = (No. o f l o n g l t u d l n a l bars) 0. 304 10.38.5 Shear . (Article 8.16.8.4) = area of an individual bar, mm2 (Article 8.25.1) = area of core of spirally reinforced compression member measured to the outside diameter of the spiral, mm2 (Article 8.18.2.2.2) = area of concrete section resisting shear trausfer, d (Article 8.16.6.4.5) = area of reinforcement in bracket or corbel resisting moment, d (Articles 8.15.5.8 and 8.16.6.8) = gross area of section, mm? **The provisions of Article 3.12, Reduction in Load intensity, were not applied in the development of the provisions presented in Articles 3.28.1 and 3.28.2. HIGHWAY BRIDGES 42 --- -- . 645 WORKING DRAWINGS .....645 MATERIALS . .81 Figure 4.6.3A Figure 4.6.5.1.lA Identification of Portions of Drilled Shafts Neglected for Estimation of Drilled Shaft Side Resistance in Cohesive Soil, Reese and O'Neill(1988) .....82 Figure 4.6.5.3.1A Procedure for Estimating Average Unit Shear for Smooth Wall Rock-Socketed Shafts, Horvath eta]. 551 Mechanical Splices ..... Bearing capacity for Seismic Loading FS 11.5 for footings on soil and rock 5.5.3 Refer to Figure 5.5.5A for computational procedures to determine the factors of safety for sliding and overturning failure modes using the Coulomb analysis. rnm 10.24.1.3 All bolts, except high-strength bolts tensioned to the requirements of Table 11.5Aor Table 11.5B, Division 11, shall have single self-locking nuts or double nuts. Zureick, A. 37 DISTRIBUTION OF WHEEL LOADS ON TIMBER FLOORING ...38 Transverse Flooring .....38 Plank and Nail Laminated Longitudinal Flooring .....39 Longitudinal Glued Laminated Timber Decks .....39 Bending Moment ..... 555 Sustained Loading Test .....555 Monotonic Loading Test ..... The reinforcement cage shall be centered in the hole using centering devices. 632 Special Installation Requirements .....633 Installation of Rocker and Roller Bearings .....633 Installation of Elastomeric Bearings ..... 179 Counterforts and Buttresses ..... 4.6.7.2 Load Testing Procedures Load tests shall be conducted following prescribed written procedures which have been developed from accepted standards (e.g., ASTM, 1989; Crowther, 1988) and modified, as appropriate, for the conditions at the site. GENERAL CONDITION FACE OF WALL FACE OF WALL OR PIER PAVEMENT SHOULDER LIMITED CONDITION *The barrier to face of wall or pier distance should not be less than the dynamic deflection of the banier for impact by a full-sized automobile at impact conditions of approximately 25 degrees and 60 miles per hour. The efficiency factor, q, shall be 1.0 where the pile cap is, or is not, in contact with the ground. 638 Measurement ..... For an eccentricity (eL)in the L direction, the actual maximum and minimum contact pressures may be determined as follows: i, = 51 1 - (nP/BLcN,) (for 4 = 0) i, = [l - P/(Q + BLc cot+)]" (4.4.7.1.1.3-2) (4.4.7.1.1.3-3) for eL< L/6: Refer to Figure 4.4.7.1.1.1A for loading definitions and footing dimensions. Temporary nongravity cantilevered walls may be constructed of reinforced concrete, metal and/or timber. .345 .. 546 General .....546 Materials and Mixing ..... Anchorage Assemblies and Couplers .....558 PROTECTION OF PRESTRESSING STEEL .....558 CORROSIONININHIBITOR .....558 .. 354 Structure Backfill .....354 Design ..... 600 Concrete .....-600 Leveling Courses ..... 238 SHEAR .....238 General ..... .131 Presumptive Ultimate Values of Load Transfer for Preliminary Design of Anchors in Soil, Modified after Cheney (1982) .....I37 Presumptive Ultimate Values of Load Transfer for Preliminary Design of Anchors in Rock, Modiied after Cheney (1982) .....I37 Default Values for the Scale Effect Correction Factor, (infinity sign*) ..... The width of the sidewalk shall be the clear width, measured at right angles to the longitudinal center line of the bridge, from the extreme inside portion of the handrail to the bottom of the curb or guardtimber. 79 4.6.2 Notations ..... .626 Steel Housing .....626 Elastomeric Rotational Element .....626 Special Fabrication Requirements for Guides .....626 Special Requirements for Load Plates . 553 SUPPLEMENTARY DRAWINGS ..... C10.50.2.1 Compact Sections where: Rb = factor computed from Equation (10-103b) using the effective transformed AfcfromEquation (4) A~ = area of the top flange AfC = transformed area of the top flange and concrete deck from Equation (4) Revisions are proposed to clarify that compact composite sections of constant-depth flexural members without longitudinal web stiffeners and without holes in the tension flange (refer to the commentary to Article 10.18.2.1.5) can qualify as compact sections for negative bending. Equations 5.6.6-3 and 5.6.6-4 are applicable for facing which is continuous over several vertical supports (e.g., reinforced shotcrete or concrete). For structures with sloping backfills, the inertial force (P,) and the dynamic horizontal thrust (PAE)are based on a height Hz near the back of the wall determined as follows: 5.8.9 Seismic Design The seismic design procedures provided herein do not directly account for the lateral deformation which may occur during large earthquake seismic loading. (1985) ..... 1.3.1.3 Relief openings, spur-dikes, debris deflectors and channel training works should be used where needed to minimize the effect of adverse flood flow conditions. 626 . .. Fillers % inch or more in thickness shall consist of not more than two plates, unless special permission is given by the Engineer. The overall stability of the retaining wall, retained slope, and foundation soil or rock shall be evaluated for all walls using limiting equilibrium methods of analysis such as the Modified Bishop, simplified Janbu or Spencer methods of analysis. Clarifying the protocol and using updated testing methods will help to minimize this problem. Scott Christie PUERTO

ultimate strength resulting from the connection where rupture is the mode of failure, and CR, is a reduction factor to account for reduced strength due to connection pullout. 8. 354 354 Scope .... 4.12.3.3.1 o b Cohesionless Soil The ultimate bearing capacity of pile groups in cohesionless soil shall be the sum of the capacities of all the piles in the group. Article 10.48.4.1) = required ratio of rigidity of one transverse stiffener to that of the web plate, nondimensional (Articles 10.34.4.7 and 10.48.5.3) = St. Venant torsional constant, mm4 (Table 10.32.1A, Article 10.48.4.1) = effective length factor in plane of buckling, nondimensional (Table 10.32.1A and Articles 10.37, 10.54.1 and 10.54.2) = constant: 0.75 for rivets; 0.6 for highstrength bolts with thread excluded from shear plane (Article 10.32.3.3.4) = buckling coefficient, nondimensional (Articles 10.34.4, 10.39.4.3, 10.48.8 and 10.51.5) = buckling coefficient, nondimensional (Article 10.39.4.4) = effective length factor in the plane of bending, nondimensional (Article 10.36) = span length, mm (Article 10.20.2.1) = distance between bolts in the direction of the applied force, mm (Table 10.32.3B) = actual unbraced length, mm (Table 10.32.1A and Articles 10.7.4, 10.15.3. and 10.55.1) = one-half of the length of the arch rib, mm (Article 10.37.1) = distance between transverse beams, mm (Article 10.41.4.6) = unbraced length, mm (Table 10.48.2.1A and Articles 10.36, 10.48.1.1, 10.48.2.1, 10.48.4.1, and 10.53.1.3) = length of member between points of support, mm (Article 10.54.1.1) = limiting unbraced length, mm (Article 10.48.4.1) = maximum unbraced length, mm (Article 10.35.1) = maximum bending moment, N-mm (Articles 10.48.8, and 10.54.2.1) = ft ftv fby H It I I, 1, 755 756 MI HIGHWAY BRIDGES = moments at the ends of a member, N-mm (Table 10.32.1A, Articles 10.36A and 10.48.4.1) column moment, Nemm (Article 10.56.3.2) calculated wind load moment, N-mm (Article 10.20.2.1) full plastic moment of the section, N-mm (Articles 10.50.1.1.2 and 10.54.2.1) lateral torsional buckling moment or yield moment, N-mm (Articles 10.48.4.1 and 10.53.1.3) elastic pier moment for loading producing maximum positive moment in adjacent span, N-mm (Article 10.50.1.1.2) maximum bending strength, N-mm (Articles 10.48, 10.51.1, 10.53.1, and 10.54.2.1) number of shear connectors (Article 10.38.5.1.2) number of additional connectors for each beam at point of contraflexure (Article 10.38.5.1.3) number of slip planes in a slip critical connection (Articles 625 Special Fabrication Requirements for Pot Bearings ....625 625 Pot .... 423 16.5.3 16.5.3.1 General Requirements .... Numerous highway bridges have been successfully fabricated using AWS D1.5, supplemented by the provisions in the AASHTO Guide Specifications for Highway Bridge Fabrication with HPS70W Steel. Unfortunately, the work of Austin was misinterpreted and his factor was applied to approximate the results of more exact in-plane second-order analyses of beam-columns. 615 Inspection at Treatment Plant .... 58 = 15 100,000 psi, Y.P. Min. Balanced Support . 208 Shear in Compression Members ....208 . 287 Stay-in-PlaceDeck Forms .... The gage for bolts in opposite legs shall be the sum of the gages from back of angle less the thickness. 519 Wales .... The former Article 10.50(f) is now Article 10.50(e). DUCTS . 340 Soil Parameters .... 344 The embedded connector shall be checked by tests as required in Article 8.31. 229 NegativeMoments . 394 Rings with rectangular cross-sections .... 394 . 203 Rectangular Sections with Tension Reinforcement Only . J Settlement of Bare , % Diameter of Bare FIGURE 4.6.5.5.1.2B Load Transfer in Tip Bearing Versus Settlement Drilled Shafts in Cohesive Soil, after Reese and O'Neill (1988) 4.6.5.6.1.3 Scour The potential for loss of lateral capacity due to scour shall be considered in the design. RepresentativeTabulated Design Values for Laminated Veneer Lumber . 486 Extent of Removal .... Steel .... The bearing capacity may also be determined using load tests. Foundation ....520 Crib Members . The first edition of the Standard Specifications was published in 1931, and it was followed by the 1935,1941, 1944,1949,1953,1957, 1961,1965,1969,1973,1977, 1983, 1989, 1992, and 1996 revised editions. .415 Live Load Bending Factor .... The vertical load shall be applied alternately upward or downward. 545 Mixing and Installation of Epoxy .... In addition to the earth, surcharge and water pressures, the backwalls of abutments shall be designed to resist loads due to impact loads. Maximum width of brush curbs, if used, shall be 9 inches. 382 Bearing Parallel to Grain .... Load Factor-A factor used to modify a nominal load effect, which accounts for the uncertainties associated with the determination and variability of the load effect. As in ASD, the compression-flange stress is used in checking for local web bend-buckling since web bend-buckling is controlled by flange strain. Specifications of the American Society for Testing and Materials (ASTM), the American Welding Society, the American Wood Preservers Association, and the National Forest Products Association are referred to, or are recognized. Placement of Reinforcing . Concrete cast in place on sand using s? estimated from SPT data using s? estimated from CPT data c. 361 Tabulated Design Values for Mechanically Graded Dimension Lumber . 237 DUCTILITY LIMITS .... 3.24.10.3 For main reinforcement perpendicular to traffic, the specified amount of distribution reinforcement shall be used in the middle half of the slab span, and not less than 50% of the specified amount shall be used in the outer quarters of the slab span. 4.4.7.1.1.2 Footing Shape For footing shapes other than continuous footings (i.e., L < 5B), the following shape factors shall be applied to Equation 4.4.7.1.1-1: In determining Pa, the effect of passive resistance provided by footing embedment shall be ignored, and BL shall represent the actual footing area in compression as shown inFigure4.4.7.1.1.IC. In addition, the bit of tension flanges be limited to a practical upper limit of 24 to ensure the flanges will not distort excessively when welded to the web. Manufacturing and Installation . The methods used for design of footings on rock should consider these factors as they apply at a particular site, and the degree to which they should be incorporated in the design. Clarifications have also been made to the allowable stresses for axial tension in members with and without holes. Factors of safety against sliding, overturning, and bearing capacity failure under seismic loading may be reduced to 75% of the factors of safety defined in Articles 5.8.2 and 5.8.3. The factor of safety for overall stability may be reduced to 1.1. (See Article 5.2.2.3.) 162 HIGHWAY BRIDGES (a) Level backf ill condition f Y k n = for ree~mur*) fa+.. J27 Simplified Earth Pressure Distributions for Permanent Flexible Cantilevered Walls with Discrete Vertical Wall Elements .... 129 Simplified Earth Pressure Distributions and Design Procedures for Permanent Flexible Cantilevered Walls with Continuous Vertical Wall Elements, Modified after Teng (1962) .... 345 SPIRAL RIB METAL PIPE . 426 General Requirements .... The present seventeenth edition constitutes a revision of the 1996 specifications, including those changes adopted since the publication of the sixteenth edition and those through 2002. The railing system shall be able to resist the applied loads at all locations. 294 Bending-Compression Interaction Coefficients .... 302 Limitations for Compact Sections . There shall be at least two fasteners in each end of lacing bars connected to flanges more than 5 inches in width. 10.30.7 Sidewalk Brackets Sidewalk brackets shall be connected to the members in such a way that the bending stresses will be transferred directly to the floor beams. 11 General .... 11 Geometry and Loads .... All portions of pedestals and shoes shall be held against lateral movement of the pins. The drilling equipment and method, use of drilling mud, type of SPT hammer (i.e., safety, donut, hydraulic) or cone penetrometer (i.e., mechanical or electrical), and any unusual subsurface conditions such as artesian pressures, boulders or other obstructions, or voids shall also be noted on the exploration logs. The AASHTO ASD compression-flange local buckling check specified in this article for the top flange during construction implicitly assumes that a load factor of approximately 1.82 (110.55) is applied to the unfactored dead loads. Floor beam connections preferably shall be located so the lateral bracing system will engage both the floor beam and the main supporting member. 175 Load Combinations and Load Factors ....175 Performance Factors ....175 GRAVITY AND SEMI-GRAVITY WALL DESIGN, AND CANTILEVER WALL DESIGN ....175 175 Earth Pressure Due to Backfill .... - ·- ~- + is used and equal to E = 0.8X 5.0 feet where a parapet is used, where X is the distance in feet from the center of the post to the point under investigation. 380 COMPRESSION MEMBERS .... These overpass structures shall comply with applicable Federal, State, and local laws. 520 Division I1 . 210 . 492 Hammer Cushion .... 130 Simplified Earth Pressure Distributions for Temporary Flexible Cantilevered Walls with Discrete Vertical Wall Elements .... 130 Simplified Earth Pressure Distributions for Temporary Flexible Cantilevered Walls with Continuous Vertical Wall Elements, Modified after Teng (1962) ....131 Quical T e r n Used in Flexible Anchored Wall Design ... 10.16.10.2 The section of the lacing bars shall be determined by the formula for axial compression in which L is taken as the distance along the bar between its connections to the main segments for single lacing, and as 70% of that distance for double lacing. 4.11.1.2 Depth The depth of footings shall be determined with respect to the character of the foundation materials and the possibility of undermining. The required strength is the combined effect of the factored loads for each applicable load combination stipulated in Article 3.22. 10.17.3 Batter b1 / c2 / 10 ~ 4U for where: S = pitch of any two successive holes in the chain; g = gage of the same holes. 449 Site Coefficient (S) . Language has been added to clarify that in addition to checking slip at overload, the bolts in slip-critical connections must also satisfy the shear and bearing strength requirements of Article 10.56.1.3 under the maximum design loads in Load Factor Design. 387 399 Bending Moment .... shall be used . 478 . 27 THERMAL FORCES .... 460 Investigation .... If using polyester reinforcement, the pH regime at the connection must be investigated and determined to be within the pH requirements for a nonaggressive environment. Structural Capacity of Pile Section ....73 Load Capacity Requirements ....37 Medianslabs .... The same is true of the webs. 68 Pedestals ....529 . 391 PTFE ....391 391 Stainless Steel Mating Surfaces . 270 Fastener Pitch in Ends of Compression Members ....271 Net Section of Riveted or High-Strength Bolted Tension Members .... 4.11.4.2.5 Effect of Load Eccentricity If the eccentricity of loading on a footing is less than y 5 of the footing width, a trapezoidal bearing pressure shall be used in evaluating the bearing capacity. 443 SECTION 3.4 ERNEL REQUIREMENTS Figure C3.2 Figure 3.2A Figure 3.2B Figure C3.5A Figure C3.5B Figure C3.5C Figure C3.5D Figure 3.10 Schematic Representation Showing How Effective Peak Acceleration and Effective Peak Velocity are Obtained from a Response Spectrum . For flange splices, the 50-inch length is to be measured between the extreme b o b b on only one side of the connection. 571 . Article 4.6.5.5.2) = standard penetration resistance, blows/m N P Q QE ep Qu q, Q (ISR) Q, 9~ = Q, Q, Q, Q, RQD = standard penetration test blow count corrected for effects of overburden, blows/m = bearing capacity factor, nondim. 424 16.5.3.4 Splices of Reinforcement . 637 Metal Beam Railing .... MSE walls shall be dimensioned to ensure that the minimum factors of safety required by Article 5.5.5 for sliding and overturning stability are satisfied. 381 Allowable Stresses .... (Article 4.6.5.1.1) reduction factor to estimate rock mass modulus and uniaxial strength from the modulus and uniaxial strength of intact rock, nondii. . 283 . If the cap is not in firm contact with the ground and if the soil is stiff, then no reduction in efficiency shall be required. 1.3.2.2 Hydrologic Analysis (a) Flood data applicable to estimating floods at site, including both historical floods and maximum floods of record. As shown in Figure 5.7.1A, the unbonded (or free) anchor length should not be less than 15 feet and should extend beyond the critical failure surface in the soil mass being retained by the anchor. 2: NOTEIFOR C0WSIK SOIL. In all cases, the subsurface conditions and soil/rock properties of the wall site shall be adequately characterized through in-sit- exploration and testing and/or laboratory testing as described in Article 5.3. Seismic forces applied to the mass of the slope shall be based on a horizontal seismic coefficient k, equal to onehalf the ground acceleration coefficient A, with the vertical seismic coefficient k, equal to zero. 164 Determination of Lateral Wall Displacements ....164 Drainage .... 1.1.2 Structural Integrity Designs and details for new bridges should address structural integrity by considering the following: (a) The use of continuity and redundancy to provide one or more alternate load paths. 4.13.4.1 109 Buckling of Drilled Shafts Stability of drilled shafts shall be considered when the shafts extend through water or air for a portion of their length. For homogeneous girders, R shall always be taken equal to 1.0. FB = specified minimum yield strength of the flange As a minimum, the splice plates for the noncontrolling flange shall be proportioned for a design stress, Fncu,Pncu shall be taken equal to a design stress, Fncu,times the smaller effective flange area, A,, on either side of the splice. Otherstandards ....618 GENERAL REQUIREMENTS ....618 MATERIALS .... 296 10.34.4 Transverse Intermediate Stiffeners .... 296 Distribution of Loads and Design of Concrete Slabs ....618 General ....618 Steel .... 296 10.34.4 Transverse Intermediate Stiffeners .... (1985),"Stability of Compact Built-Up Struts: Experimental Investigation and Numerical Simulation," Construzioni Metalliche, No. 4. ~ 269 Perforated Cover Plates ....269 Stay Plates . 30.65 ksi Rcu = IFC"~(Fu) = (37.50) 15.241 = 2.46 Rcufncu = (2.46)(12.46) = 30.65 ksi = ...=0.5(69.0)~~(1.0(-37.50) - 30.65) 12 = 13,519 kip-in. For the governing web pier, the full shear strength of the wall shall be used to determine the skin friction resistance, the total base area of the equivalent pier shall be used to determine the end bearing resistance, and the additional capacity of the cap shall be ignored. Dead load surcharges, if present, shall be taken into account in accordance with Figures 5.8.12.1A, 5.8.12.1.B, and 5.8.12.1C. 204 Other Cross Sections . The earth pressures on anchored walls constructed in fill situations from the bottom up are affected by the method and sequence of construction. tabulated values shall bc reduced 20 percent. Class A, B, or C surface conditions of the bolted parts as defined in Table 10.32.3C shall be used in joints designated as slip-critical except as permitted in Article 10.32.3.2.2. 10.32.3.1.1 Bolted bearing-type connections shall be used only for members in compression and secondary members. 225 . 184 .... 542 Class Manufactured Finish .... For cases where the number of longitudinal stiffeners exceeds two, it is suggested that additional transverse stiffeners (beyond the recommended transverse stiffeners placed near points of dead load contraflexure) be added to reduce the required size of the longitudinal stiffeners to a more practical value. 633 Installation of Anchorages .... For most cases, elastic analysis will be applicable for design provided the stress levels in the shaft are moderate relative to (ƒ.,. 4.12.3.3.4 Piles Bearing on Rock For piles driven to weak rock such as shales and mudstones or poor quality weathered rock, the ultimate tip capacity shall be estimated using semi-empirical methods. The block mechanism for cohesionless soil shall be taken as provided in Figure C4.12.3.7-2-1 and for cohesive soils as given in Figure C4.12.3.7.2-2. Therefore, the reinforcement load, accounting for the influence of shear stress, shall be calculated using a Simplified Coherent Gravity approach. 342 CORRUGATED METAL PIPE ....342 General .... 435 - FIGURE 5.8.2B External Stability for Wall with Sloping Backslope HIGHWAY BRIDGES I-Ii F P, = 5,5,2 cos(1) F*V FT cos (1 = m FOR INFINITE SLOPE I K, For Retained F11 l Using B = B = 1 (See Figure 5.5.2A) I Sm2 OSeno1 - 8) = 1n(+*+8) Sln (9'- I S1d8 8)Sln(O +l - AGAINST OVERTURNING (MOMENTS ABOUT POINT 018 v, (L/2) + v2(2L/3) + Fv (L) X Moments R e r l r t r n ~(Mr) r 2.0 Z Moments Overturnrng (Mo) F, (h/3) FACTOR OF SAFETY F S ~ .= - FACTOR OF SAFETY AGAZNST SLIDINGB F s= ~ X Horrzontal Rekstrnq Force(.) T~tlorlzontal Orivrng Force(.) * = F r r c t l o n Angle o f Reinforced = (V, +V2 +F,)(Ten P o r Ten FH zld R e c k l l l o r Foundation. 431 SoilDesign . 292 Fatigue .... 231 LOAD FACTORS .... 113 Mechanically Stabilized Earth Walls .... 2.5.1 railing or barrier with a pedestrian railing along the edge of the structure. 193 PART B ANALYSIS . Pedestals and shoes shall be so designed that the load will be distributed uniformly over the entire bearing. For webs, FH shall be taken equal to a design stress, Fncu, equal to the smaller effective flange area, A,on either side of the splice. 389 Limits on Contact Stress for PTFE . 10 Elastic Constants of Various Soils, Modified after U.S. Department of Navy (1982) and Bowles (1982) . 503 Construction Tolerances .... Earth Loads . 4.4.1.3 Footings in Fill Footings located in fill are subject to the same bearing capacity, settlement, and dynamic ground stability considerations as footings in natural soil in accordance with Articles 4.4.7 through 4.4.7.5. The behavior of both the fill and underlying natural soil shall be considered. 613 PAINTING . 487 General .... 487 Drawings .... If this is the case, the surrounding soils shall also meet the chemical criteria required for the backfill material if the environment is to be considered nonaggressive, or adequate long-term drainage around the geosynthetic reinforcement shall be provided to ensure that chemically aggressive liquid does not enter into the reinforced backfill. In pin-connected trusses, if the floor beams are located below the bottom chord pins, the vertical posts shall be extended sufficiently below the pins to make a rigid connection to the floor beam. 223 SECTION 9-PRESTRESSED CONCRETE Table 9.16.2.2 Estimate of Prestress Losses .... 659 Structural Plate .... 391 391 Cylindrical or Spherical Bearings .... 536 Premolded Expansion Joint Fillers .... Generally, a larger number of parallel girders require stronger bracing than would a fewer number of girders. The face walls (or stems) shall be securely anchored to the supporting counterforts or buttresses by means of adequate reinforcement. 628 Long-term Compression Proof Load Test . The corresponding LFD compression-flange local buckling check (Article 10.61.4) is made using a load factor of 1.3 applied to the unfactored dead loads. Capers, Jr., Richard W. 583 . 623 18.1 18.2 18.2.1 18.2.2 18.2.3 18.3 18.4 18.4.1 18.4.1.1 18.4.2 Division I1 Division I1 CONTENTS Ix Fabric-Reinforced Elastomeric Bearings . 623 Dead Load . In this case, the neutral axis lies outside the web. There shall be enough pin plates on forked ends to make the section of each jaw equal to that of the member. 278 HIGHWAY BRIDGES F,e-l = 1 ~ Equation for 19.30.1A . 623 . A lesser FS, of 2.0, could be used if justified Compound Stsb111q Failure surfacer l I I I I I I I I I I I I I I I I I I I I/'/ / / / l l/ / / / 0 0 0 / / 0 0 0 0 / / / / / # / 0 0 / / / 0 There is no known theoretical reason for 19991200 COMMENTARY using the subpanel depth in these requirements. For trusses and girders: Spans 50 feet in length or less; 2 bolts, 1 inch in diameter, or 10 inches in the masonry. The net section back of the pin hole shall not be less than 75% of the required net section of the body of the member. Unless E, varies significantly with depth, E, should be de- 4.4.7.2.2 terminated at a depth of about % to Y3 of B below the footing. 2.7.1.3.5 Rail members shall be designed for a moment, due to concentrated loads, at the center of the panel and at the posts of PL16 where L is the post spacing and P' is equal to P, Pl2, or Pl3, as modified by the factor C where required. If the footing width is small relative to the thickness of a compressible soil, the effect of three-dimensional loading shall be considered. 570 Division II Division I1 CONTENTS Direction of Rolling .... the modulus of rupture of concrete, as defined in Article 9.15.2.3, MPa (Article 9.18) total prestress loss, excluding friction, MPa (Article 9.16) specified ultimate tensile strength of the prestressing steel, MPa (Article 9.17.4) average stress in prestressing steel at ultimate load, MPa (Article 9.17 A) 299 . 298 10.34.6 Bearing Stiffeners . P, Splices shall be in conformance with the re8.32gquirements 4.6.6.2.3 Tension Reinforcement shall be designed to resist stresses caused by fresh concrete flowing from inside the cage to the side of the excavated hole. C10.34.4 Transverse Intermediate Stiffeners An editorial revision is indicated to clarify the definition of the bending requirement (referred to in following articles). To prevent unequal settlement, footings shall be designed to keep the bearing pressure as nearly uniform as practical. 477 CONSTRUCTION .... 260 DEFLECTION .... 260 LIMITING LENGTHS OF MEMBERS ....263 MINIMUM THICKNESS OF METAL ....265 EFFECTIVE AREA OF ANGLES AND TEE SECTIONS IN TENSION .... Perimeter Grout .... 26 Potential equal TABLE 10323B Allowable Stresses on High-Strength Bolts or Connected Material (ksi) "Applies to fastener cross-sectional a is based on a nominal body diameter. V. Footings on rocks are considered to be adequate against bearing capacity failure if the product of the ultimate bearing capacity determined using procedures described in Articles 4.11.4.2.1 through 4.11.4.2.3 and an appropriate performance factor exceeds the effect of design loads. General .... 537 Roadway Surface F i s h 320 Longitudinally Stiffened Girders .... 321 Bearingstiffeners .... unconfined compressive strength of rock mass or concrete, whichever is weaker. The embedment of the reinforcement into the cap shall be in conformance with Articles 8.24 and 8.25. H t h e t o t a l w a l l h e i g h t a t t h e f a c e. This inertial force is distributed to the reinforcements proportionally to their resistant areas on a load per unit of wall width basis as follows: Ac tive (5.8.9.2-1) xed As shown in Figure 5.8.9.2A, the total load applied to the reinforcement on a load per unit of wall width basis is as follows: is determined using Equation 5.8.4.1-3. 575 General .... The estimation of seismic design forces shall account for wall inertia forces in addition to the equivalent static forces. 630 Material Certification Tests .... 630 Testing by the Engineer .... 630 Bearing Tests .... 630 Test Requirements for Elastomeric Bearings .... 630 Scope .... 630 Frequency of Testing .... 630 Ambient Temperature Tests on the Elastomer .... 631 Low Temperature Tests on the Elastomer .... 631 Visual Inspection of the Finished Bearing .... 631 Short-Duration Compression Tests on Bearings .... 631 Long-Duration Compression Tests on Bearings .... 631 Shear Modulus Tests on Materials from Bearings . Furthermore, differential settlements between the facing elements and the soil behind the facing wall (for concentrated bearing stresses from the facing weight on soft soil could create concentrated stresses at the connection between the facing elements and the wall backfill reinforcement. 4.6.5.3.1 Bolted Bearing-type connections shall be used only for... Bevels can be provided in Article 5.8 to satisfy ... an adequate factor of safety ... is defined in Table 5.8.3B, . as well as overall stability requirements as provided in Article 5.2.2.3. The total embedment length shall be calculated based on external and internal stability considerations in accordance with Articles 5.2.2.3 and 5.5.5, and all relevant portions of Article 5.8. Soil reinforcement length shall be as a minimum approximately 70% of the wall height (as measured from the leveling pad) and not less than 2.4 meters (8 feet). An MSE wall with welded wire or geosynthetic facing can tolerate the most deformation. 69 Estimated and Minimum Tip Elevation .... 69 Piles Through Embankment Fill .... The curves presented indicate the proportions of the ultimate side resistance (Qs) and ultimate tip resistance (Qt) mobilized at various magnitudes of settlement. GREATER THAN APPROACH TRAVELLED WAY BUT NOT LESS THAN 24 FT. To compute the allowable bending stress for the flange, the full flange width is to be conservatively used. Oversize holes shall not be used in bearing-type connections. in M 102 To 20 M 102 To 20 M 102 To 10 M 102 To 20 da. T or Rev E 16 Base metal at gross section of high-strength bolted slip resistant connections, except axially loaded joints which induce out-of-plane bending in connecting materials. 10.24.4.4 Structural shapes which do not admit the use of %-inch diameter fasteners shall not be used except in handrails. 10.18.2.1.7 Riveted and bolted flange angle splices shall include two angles, one on each side of the flexural member. Dimensions for Minimum Support Length Requirements . By judicious placement of the longitudinal stiffener in regions of stress reversal, it may be possible to place only one stiffener on the web (rather than two) such that the stress and stability criteria are adequately satisfied with either side of the web in compression. 632 Cost of Transporting ....632 Use of Tested Bearings in the Structure ....632 PACKING, SHIPPING AND STORING ....632 INSTALLATION ....632 Tabulated Members Requirements .... where, NL = number of design tr&~c lanes (Article 3.6); NB = number of beams (4 5 NB5 10); S = beam spacing in feet (6.57 5 S 5 11.00); L = span length in feet; k = 0.07 W - NL (0.IONL - 0.26) - 0.20NB - 0.12; (S 34) W = numeric value of the roadway width between curbs expressed in feet (32 5 W 5 66). 478 Figure 27.5D Figure 27.5E SECTION 30-THERMOPLASTIC PIPE Figure 30.5.1 Untitled .... 386 Design Requirements ....387 GENERAL REQUIREMENTS FOR BEARINGS ....387 Load and Movement Capabilities .... Eyebars .... Though the specifications in Division IA regarding this issue are directed at structural gravity and semi-gravity walls, these specifications may also be applicable to other types of gravity walls regarding this issue provided the two conditions listed above are met. Both total and effective stress methods may be used provided the appropriate soil strength parameters are evaluated. 10.8 MINIMUM THICKNESS OF METAL 506.396 "Average Daily Truck Traffic (one direction). On wide flood plains, lowering of approach embankments to provide overflow sections that would pass unusual floods over the highway is a means of preventing loss of structures. Cyclic Loading Test .... 274 HIGHWAY BRIDGES 10.18.2.2.2 As a minimum, in the case of the strength design method, high-strength bolted connections for both top and bottom flange splices shall be proportioned to prevent slip at an overload design force, Pfo.For the flange under consideration, Pfoshall be computed as follows: where: , f = maximum flexural stress due to D + P,(L + I) at the mid-thickness of the flange under consideration for the smaller section at the point of splice, where p, is defined in Article 3.22 R = reduction factor for hybrid girders specified in Article 10.53.1.2. R shall be taken equal to 1.0 when fos less than or equal to F, where F, is equal to the specified minimum yield strength of the web. In both cases, the leveling pad shall be embedded adequately to meet bearing capacity, settlement and stability requirements. C10.34.4.2 The longitudinal stiffener is designed to keep bearing stresses beneath the leveling pad and the residual of the wall as uniform as possible. The revised change has indicated that this location may not necessarily correspond to the extended optimum location of the stiffener specified in Article 10.49.3.2(a). The allowable reinforcement tension shall be based on a strength greater than or equal to 5,000 ohm-cm, chlorides and sulfate requirements may be waived. 4.11.4.1.6 Effect of Groundwater Table Ultimate bearing capacity shall be determined using the highest anticipated groundwater level at the footing location. 497 Basis of Payment .... Allowable Stresses .... 569 FABRICATION .... 84 4.6.5.3.1 Side Resistance . 650 Filter Fabric .... 650 Geocomposite Drain System . 318 Partially Braced Members .... 535 EXPANSION AND CONTRACTION JOINTS .... In metal less than % inch thick, countersunk fasteners shall not be assumed to carry stress. Mortar 603 604 Grout .... Furthermore, the top of the flexible facing panel at the top of the wall shall be attached to a soil reinforcement layer to provide stability to the top facing panel. 422 16.4.6.6.1 Radial Tension Stirrup Anchorage ....423 16.4.6.6.3.2 Shear Stirrup Anchorage ....423 16.4.6.6.4.5 Other Provisions .... 4.6.6.2.5 ~eidencementCover The reinforcement shall be placed a clear distance of not less than 2 inches from the permanently cased or 3 inches from the uncased sides. 516 Timber .... .C.42 Acceleration Coefficient-Continental United States ......447 Acceleration Coefficient-Alaska, Hawaii andPuertoRico . fcu = maximum elastic flexural stress due to the factored loads at the mid-thickness of the controlling flange at the point of splice. 57 57 4.4.7.2 Settlement .... 272 Truss Chords and Columns .... > Transition radius 2 6 in. 4.12.3.3 Resistance at Strength Limit States The strength limit states that shall be considered include: -bearing capacity of piles, -uplift capacity of piles, -punching of piles in strong soil into a weaker layer, and -structural capacity of the piles. (1983) ....85 Figure 4.6.5.5.1.lA Load Transfer in Side Resistance Versus Settlement Drilled Shafts in Cohesive Soil, after Reese and O'Neill (1988) .. C10A0,3 PlateThickness Reqoirements This revision ensures that only the computation of the compression-flange width-to-thickness ratio for a hybrid girder (in ASD) is affected by the hybrid reduction factor R. 10.24.6 Maximum Spacing of Sealing and Stitch Fasteners 10.24.6.1' Sealing Fasteners For sealing against the penetration of moisture in joints, the fastener spacing along a single line of fasteners adjacent to a free edge of an outside plate or shape shall not exceed 4 inches 4t or 7 inches. 667 PAYMENT ....667 SECTION 27-CONCRETE CULVERTS 27.1 GENERAL ....669 Division II Division I1 CONTENTS WORKING DRAWINGS . 661 Joint Properties .... E HIGHWAY BRIDGES 763 764 HIGHWAY BRIDGES APP. The forms shall be designed to be elastic under construction loads. However, in situations where the actual stiffener spacing is used to compute J and I, the stiffener moment of inertia that is provided may not be suficient if the stiffener was originally designed based on the earlier criteria. Portions of the walls below the level of the drainage system shall be designed for full hydrostatic pressure unless a deeper drainage system is provided behind and at the base of the wall. 432 Handling and Installation Strength ....433 LOADFACTORDESIGN .... This may be accomplished by limiting the size of individual panels vertically and the vertical spacing of the soil reinforcement layers, and by requiring the facing panels to have an adequate amount of vertical slip between adjacent panels. Based on this figure, the multiplier to K, is a function of the reinforcement type and the depth of the reinforcement below the wall top. .75 Timberpiles ....75 Spacing, Clearances, and Embedment ....75 PileFootings . C10.53.2 Composite Hybrid Sections The word 'girders' is replaced with the more appropriate word 'sections' in the heading for this article. 30 EARTH PRESSURE .... Base metal and weld metal in or adjacent to full penetration groove weld splices at transitions in width or thickness, with welds ground to provide slopes no steeper than 1 to 2%, with grinding in the d i i t i o n of the applied stress, and weld soundness established by nondestructive inspection: (a) AASHTO M 270 Grades 1001100W (ASTM A 709) T or Rev base metal T or Rev (b) Other base metals Base metal and weld metal in or adjacent to full penetration T or Rev groove weld splices, with or without transitions having slopes no greater than 1 to 2%, w h e n the reinforcement is not removed and weld soundness is established by nondestructive inspection. .,...................................... Stringers preferably shall be framed into floor beams. 395 Steel Reinforced Elastomeric Bearings-Method B . Underwater Placement . 10.33.1 General 10.34.2 Flanges 10.32.6.3 For allowable unit-bearing stress on concrete masonry, refer to Article 8.15.2.1.3. 10.33.1.1 Rolled beams, including those with welded cover plates, shall be designed by the moment of inertia method. Pockets shall be provided with effective drain holes or be filled with waterproofing material. 84 4.6.5.3 Axial Capacity in Rock . 687 ASSEMBLY . 5.3.2 Minimum Depth 5.4 NOTATIONS Regardless of the wall foundation type, borings shall extend into a bearing layer adequate to support the anticipated foundation loads, defined as dense or hard soils, or bedrock. Transverse Reinforcement . 412 Ultimate D-load . p Py 0 C, $. This revision eliminates the requirement to use the maximum subpanel depth instead of the total panel depth when designing the transverse stiffeners on longitudinally stiffened girders. (Articles 8.15.2.1.3 and 8.16.7.2) = width of corhpression face of member, mm = perimeter of critical section for slabs and footings, mm (Articles 8.15.5.6.2 and 8.16.6.6.2) = width of cross section at contact surface being investigated for horizontal shear, mm (Article 8.15.5.5.3) = web width, or diameter of circular section, mm (Article 8.15.5.1.1) = distance from extreme compression fiber to neutral axis, mm (Article 8.16.2.7) = factor relating the actual moment diagram to an equivalent uniform moment diagram (Article 8.16.5.2.7) The specifications of Section 8 are patterned after and arc in general conformity with the provisions of ACI Standard 318 for reinforced concnte design pnd its commentary. For unstable ground, detailed explorations, testing and analysis are required to evaluate potential additional lateral loads due to slope movements. CONTENTS .... ed h&&om using high-strength boltsin sloned hols with the load mlied in adirectionotherthan approximatelynormal (betwax 80 and fbb degrees) to the ads of thihole and connections with bolts in wersized holes shall bc designed for resistance agaiust slip in accordance with Artide 10.32.3.2.1. & is equal to the dear distance between the holes or between the hole and the edge of the material in the direction of the applied bearing force, in. Clay (where shear strength is less than 0.5 times normal pressure) using shear strength measured in lab tests using shear strength measured in field tests using shear strength estimated from CPT data d. 696 %Plastic Section Modulus .... Each traffic post shall also be designed to resist an independently applied inward load equal to one-fourth the outward transverse load. 146 Determination of Reinforcement Tensile Load at the Connection totheWdFace .... 536 Metal Armor ....536 Waterstops .... 6. Failure by sliding shall be considered by comparing the tangential component of force on the footing (P) to the maximum resisting force (P a by the following: for L/6 < eL< Ll2: For an eccentricity (ep) in the B direction, the maximum and minimum contact pressures may be determined using Equations 4.4.7.1.1.1-4 through 4.4.7.1.1.1-8 by replacing terms labeled L by B, and terms labeled B by L. 453 SELECTION OF ANALYSIS METHOD ....453 Special Requirements for Single-Span Bridges and Bridges in SPC A . Dl235 10.34.3.2.2 DIVISION I-DESIGN 90,000 psi, Y.P. Min. 4.13.3.1 DIVISION I-DESIGN 4.13.3.1 Factors Affecting Axial Capacity See Article 4.6.5.2 for drilled shafts in soil and Article 4.6.5.3.3 for drilled shafts in rock. Description . 670 Joints . Protection of Existing Structures . C10.48.4 Partially Braced Members The current web thickness requirement given by existing Equation (10-100) is eliminated. 272 General .... 2.7.2.2 Geometry and Loads 2.7.2.2.1 The minimum height of a railing used to protect a bicyclist shall be 54 inches, measured from the top of the surface on which the bicycle rides to the top of the top rail. 521 Facing . It is further indicated that procedures to check these members for these Language has been added at the end of footnote e in order to clarify the definition of the 50-inch length used in determining whether or not to apply the joint-length correction factor when calculating the shear strength of highstrength bolts in flange splices. Where combined horizontal and vertical displacements are possible, horizontal movements should be limited to 1 inch or less. The Federal Highway Administration and the States have established a goal that the LRFD standards be used on all new bridge designs after 2007; only edits related to technical errors in the seventeenth edition will be made hereafter. Rigid gravity and semi-gravity retaining walls may be used for bridge substructures or grade separation. 69 Design Terminology .... Checking these requirements using the factored noncomposite dead load compression flange stress fb in place of Fy is redundant since web bend-buckling is already explicitly checked, as mentioned earlier. The width at ends of tapered cover plates shall be not less than 3 inches. Critical Buckling of Liner Plate Wall . ~ i ~ l ~ cor ance 10.16.14 Net Section of Riveted or High-Strength Bolted Tension Members 10.16.14.1 The net section of a riveted or highstrength bolted tension member is the sum of the net sections of its component parts. To achieve F,, equal to Fy at critical sections, the compression flange slenderness (based on the full flange width b) cannot exceed the limiting values indicated in revised Table 10.48.2.1A. The facing elements shall be stabilized such that they do not deflect laterally or bulge beyond the established tolerances. For members primarily in bending, the entire gross section shall be used when calculating tensile and compressive stresses. 10.33 ROLLED BEAMS 10.34.1.2 The compression flanges of plate girders supporting timber floors shall not be considered to be laterally supported by the flooring unless the floor and fastenings are specially designed to provide support. N pu (Article 10.54.1.1) = allowable bearing, Nlmm (Article P 10.32.4.2) Q = prying tension per bolt. The word 'SYMMETRICAL' in the existing heading is a misnomer since many of the provisions in this article can be applied to both symmetric and singly symmetric girders. This method is being eliminated by many owners due to the complexity of the code with many new material grades. 673 Haunch, Lower Side and Backfill or Overfill . 381 Tapered Columns .... .208 Shear in Lightweight Concrete ....208 Shear Strength Provided by Shear Reinforcement ....208 ShearFriction ....209 Shear-Friction Design Method ....209 Horizontal Shear Strength for Composite Concrete FlexuralMembers .... 499 MATERIALS ....500 Concrete . Method A-Empirical Pile Formulas ....494 Method B-Wave Equation Analysis ....494 495 Method C-Dynamic Load Tests .... 94 Performance Factors for Geotechnical Strength Limit States in Axially Loaded Piles .... 88 Soil Layering .... 5.5.7 5.6.2 BacW The backfill material behind all retaining walls shall be free draining, nonexpansive, noncorrosive material and shall be drained by weep holes with french drains or other positive drainage systems, placed at suitable intervals and elevations. 4.13.3.2.2 Tolerable Movement The provisions of Article 4.12.3.2.2 shall apply as applicable. 93 Scour Protection ....93 Frost Action . At the connection with the wall face, T, shall be determined at the wall face connection in accordance with Article 5.8.7.1 for steel reinforcement and Article 5.8.7.2 for geosynthetic reinforcement. The elastic deformation caused by the dead load of the forms, plastic concrete and reinforcement shall not exceed a deflection of greater than L1180 or % inch for form work spans (L) of 10 feet or less, or a deflection of L1240 or % inch for form work spans (L) over 10 feet. FIGURE 4.4.8.1.1A Allowable Contact Stress for Footings on Rock with Tight Discontinuities Peck, et al. Rock is defined as soft when the uniaxial compressive strength of the weaker rock is less than 20% of that of the stronger rock, or weathered when the RQD is less than 20%. In those cases where a New Jersey type parapet or a curb is constructed on a bridge, particularly in urban areas that have curbs and gutters leading to a bridge, the same widths between curbs on the approach roadways will be maintained across the bridge structure. 456 Mode Shapes and Periods .... Ninth Edition, 1989, American Institute of Steel C~ll~truction. 16.4.4.2.2 Pipe Fluid Weight . A similar upper limit is specified in Article 6.10.7.4.4~of the AASHTO LRFD Bridge Design Spec$cations. 418 16.4.6.6.1 Reinforcement for Flexural Strength .... The prying force shall not exceed 60% of the externally applied load. The formula assumes that both flanges are the same thickness and uses the thickness of only one flange. .639 . 301 10.37 SOLID RIB ARCHES .... The amount of total and differential vertical deflection that can be tolerated depends on the wall facing material, configuration, and timing of facing construction. A new companion CD-ROM with advance search features is included with each book. R = reduction factor for hybrid girders specified in Article 10.53.1.2. R shall be taken equal to 1.0 when f,, is less than or equal to F, where F, is equal to the specified minimum yield strength of the web. If a break in the slope behind the wall facing is located horizontally within two times the height of the wall (2H), a broken backslope design (A.R.E.A. method) shall be used, as illustrated in Figure 5.8.2.C. Alternatively, a broken back slope design can be performed for the actual slope geometry by using a graphical Coulomb procedure such as the Culmann method. 80 4.6.4.1 Presumptive Values .... 10.16.11.4 Listed below are the values of the expression 11,000/* for the following grades of steel: 36,000 psi, Y.P. Min 58 50,000 psi, Y.P. Min 49 70,000 psi, Y.P. Min 42 90,000 psi, Y.P. Min 37 100,000 psi, Y.P. Min 35 10.16.12 Half-Through Truss Spans 10.16.12.1 The vertical truss members and the floor beams and their connections in half-through mss spans shall be proportioned to resist a lateral force of not less than 300 pounds per linear foot applied at the top chord panel points of each truss. C10.61.1 C-135 Web Bend-Buckling The indicated revision is made in LFD to be consistent with a similar revision made in ASD (see the previous discussion on the revisions to ASD Article 10.3.1). Lateral bracing between at least one pair of girders over a portion of each span may provide the necessary shear restraint to prevent the girders from deflecting laterally in unison. If the grip exceeds six times the diameter of the rivet, specially designed rivets shall be used. 2.7.4 Structural Specifications and Guidelines 2.7.4.1 Railings shall be designed by the elastic method to the allowable stresses for the appropriate material. 10.32.2 Weld Metal Unless otherwise specified, the yield point and ultimate strength of weld metal shall be equal to or greater than minirnum specified value of the base metal. Earlier versions of the Standard Specifications indicated that the required stiffener spacing was to be used in calculating the term J given by Equation (10-32). It is considered to be too conservative to use this increased computed flange stress to check for local buckling of the web. 4.4.5.1 Minimum Embedment and Bench Width ....48 4.4.5.2 Scour Protection .... 174 NOTATIONS .... 575 575 Measurement of Curvature and Camber .... Since this limit does not represent the maximum permitted web slenderness, but is only used to determine if local web bend-buckling has occurred, an upper limit on the web slenderness is not specified. 426 Modification of Earth Loads for Soil-Structure Interaction ....426 Embankment Installations .... 335 ORTHOTROPIC SUPERSTRUCTURES ....335 CONSTRUCTIBILITY ....336 WebBendBuckling .... The face of the guardrail or other device shall be at least 2 feet 0 inches outside the normal shoulder line. 398 Reinforcement .... 78 4.6.1.4 Embedment .... Deterioration of the concrete in a foundation by sulfate, chloride, and acid attack should be investigated. 67 Transfer of Force .... 195 Design Methods .... 4.6.5.3.3.2 Rock Mass Discontinuities The strength and compressibility of rock will be affected by the presence of discontinuities (joints and fractures). 323 Positive Moment Sections ....324 Compact Sections ....324 Noncompact Sections ....325 Negative Moment Sections .... 2837-2849. As a general guide, the effects of group action for in-line CTC < 8B may be considered using the ratios (CGS, 1985) appearing on page 89. 493 Preparation of Piling .... -37.50 ksi = 1,127 kip-ft H,,=O.5(69.0)((1 .0)(-37.50) + 30.65) 2 = -118.2 kips HIGHWAY BRIDGES C-116 SPLICE-DESIGN REQUIREMENTS Use V,, Mvu,Mwuand Hwuto check: 1) shear resistance of the bolts 2) bearing resistance at bolt holes Ps= VwuINb(N, = no. b'lt 100,000 psi, Y.P. Min. 359 DESIGN VALUES ....360 General ....360 Tabulated Values for Sawn Lumber ....360 Stress Grades in Flexure ....360 Tabulated Values for Glued Laminated Timber . When using strength design methods, the theoretical end of the cover plate is the section at which the flange strength without that cover plate equals the required strength for the design loads, exclusive of fatigue requirements. In general, splices whether in tension, compression, bending, or shear, shall be designed in the case of the service load design or strength design methods for a capacity based on not less than the average of the required design strength at the point of splice and the design strength of the member at the same point but, in any event, not less than 75% of the design strength of the member, except as specified herein. If there is a truss, girder, or parapet wall adjacent to the roadway curb, the width shall be measured to the extreme walk side of these members. 509 UnbondedLength .... Support Condition Coefficients for Tapered Columns .....382 SECTION 14-BEARINGS Table 14.5.2.1 Table 14.6.2.4.1 Table 14.6.2.5. 1 Bearing Stability .... 660 Protective Coatings .... stress as the web at their vertical location on the web and must have sufficient rigidity and strength to resist bendbuckling of the web. 307 10.39.3.1 10.39.3.2 Secondary Bending Stresses ....308 10.39.4 Design of Bottom Flange Plates .... The enlarged base shall slope at a side angle not less than 30 degrees from the vertical and have a bottom diameter not greater than 3 times the 4.6.6.3 DIVISION I-DESIGN diameter of the shaft. 477 WORKINGDRAWINGS . 340 Pipe Arch Design .... Tolerable movement criteria for foundation settlement shall be developed considering the angular distortion 61 (S1/l) between adjacent footings. The base slabs of cantilever walls shall be designed as cantilevers supported by the wall. CONTENTS . Anchors may be prestressed or deadman type elements composed of strand tendons or bars (with corrosion protection as necessary) extending from the wall face to a ground zone or mechanical anchorage located beyond the zone of soil applying load to the wall. It was decided not to include these additional specification requirements at this time. 401 Design Basis .... When the top flange is composite, the stresses that are shed from the web to the flange are resisted in proportion to the relative stiffness of the steel flange and the concrete deck. .483 . 93 Depth .... 645 .. 25,000,000 10.32.5.3 Cast Iron Cast iron castings shall conform to specifications for Gray Iron Castings, AASHTO M 105 (ASTM A 48), Class 30B. Table 11.5A or Table 11.5B, shall have single self-locking nuts or double nuts. (c) Distribution of flow and velocities at site for flood discharges to be considered in design of structure. 4.12.4.1 Buckling of Piles Stability of piles shall be considered when the piles extend through water or air for a portion of their lengths. 493 Pile ShoesanUugs .... Silts and clays shall not be used for backfill unless suitable design procedures are followed and construction control measures are incorporated in the construction documents to account for their presence. 3.24.3.2 Case B-Main Reinforcement Parallel to Traffic For wheel loads, the distribution width, E, shall be (4 0.06s) but shall not exceed 7.0 feet. 500 Division I1 CONTENTS li_- . 525 CLASSES OF CONCRETE .... In bridges with wooden floors and steel stringers, intermediate cross frames (or diaphragms) shall be placed between stringers more than 20 feet long. For other limitations, see Article 10.35.2. 10.11 EXPANSION AND CONTRACTION In all bridges, provisions shall be made in the design to resist thermal stresses induced, or means shall be provided for movement caused by temperature changes. "ThreeDimensional Modeling of Concrete Structures. These product specific studies shall be used to estimate the short-term and long-term effects of these environmental factors on the strength and deformational characteristics of the geosynthetic reinforcement throughout the reinforcement design life. Determine the depth (point a) at which the shear in the wall is zero (i.e., the point at which the areas of the d~ivingand resisting pressure diagrams are equivalent). 383 .. 86 4.6.5.5 Deformation of Axially Loaded Shafts . .554 Wire .... 10.30.2 Floor Beams Floor beams preferably shall be at right angles to the trusses or main girders and shall be rigidly connected thereto. .547 . 5. C10.53.1.2 Braced Noncompact Sections The indicated revisions in this new LFD article parallel the revisions to ASD Article 10.39 (see the earlier discussion on the proposed revisions to Article 10.39). incl. The local buckling capacity of the stiffener, Fa, is given by Equation (10-32b). IKLIWTION oc m oc V ~ vLt m AE~CECT to nonlfOnrry. Embedment in intact rock, including massive to appreciably jointed rock which should not fail through a joint surface, should be based on an allowable shear strength of O.lOCo to 0. .396 SECTION 15 - S T E E L TUNNEL LINER PLATES Table 15.3.2.2 Table 15.5A Table 15.5B Untitled .... 682 Curing . 5.8.5.2 DIVISION I-DESIGN 149 m O ~ en so t ~ n c l u d epolymer s t r i p reinforcement FIGURE 5.8.4.1C Variation of the Coefficient of Lateral Stress Ratio KJK, with Depth in a Mechanically Stabilized Earth Wall The effective pullout length required shall be determined using the following equation: where Le is the length of reinforcement in the resisting zone, FSpois the safety factor against pullout (minimum of IS), F* is the pullout resistance factor, a is a scale effect correction factor, a, is the vertical stress at the reinforcement in the resistant zone, C is an overall reinforcement surface area geometry factor based on the gross perimeter of the reinforcement and is equal to 2 for strip, grid, and sheet type reinforcements (i.e., two sides), R, is the reinforcement coverage ratio (see Article 5.8.6), and other variables are as defined previously. 5.2.1.5 Prefabricated Modular Walls Prefabricated modular wall systems, whose elements may be proprietary, generally employ interlocking soilfilled reinforced concrete or steel modules or bins, rock filled gabion baskets, precast concrete units, or dry cast segmental masonry concrete units (without soil reinforcement) which resist earth pressures by acting as gravity retaining walls. 244 Ties . 329 Compact Sections .... The revised b/t limits in Table 10.48.2.1Arepresent the compression-flangeslenderness ratios below which F, is equal to F,, where F, is defined in revised Article 10.48.2 (and discussed above). 3 Design Analysis .... 183 PART B-SERVICE LOAD DESIGN METHOD ALLOWABLE STRESS DESIGN 7.3 7.3.1 PIERS .... The she& in steel girder webs shall not exceed 0.58 F,.D&C for this single truck loading. Spans of 50 feet or greater shall be provided with a type of bearing employing a hinge, curved bearing plates, elastomeric pads, or pin arrangement for deflection purposes. The slip resistance per unit area shall be taken as equal to the slip resistance per unit area from Table 10.32.3C for Class A coatings as appropriate for the hole type and bolt type times the slip coefficient determined by test divided by 0.33. G. = 2.12 Shear in girder webs, gross section F. 466 Column and Pile Bent Design Forces . 273 Flange Splices .... Should the concrete not be considered fully effective for negative moment in computing the longitudinal stress range, an option is provided to allow the engineer to include only the area of reinforcement (in com- C-123 C10.39.4.2 Compression Flanges Unstiffened Equation (10-74) for the allowable stress of unstiffened box-girder com ression flanges is to apply between blt ratios of 6,140/& and 13,300/& to be consistent with similar LFD provisions for unstiffened compression flanges. Special Requirements for Anchor Bolts .... Reduced shear strength values shall be used to determine q2in accordance with Article 4.4.7.1. If the upper layer is a cohesionless soil and +' equals 25" to 50°, Equation 4.4.7.1.1.7-3 reduces to The critical depth of the upper layer beyond which the bearing capacity will generally be unaffected by the presence of the lower layer is given by the following: I-&,., = [3B ln(q,/q2)]/[2(1+ BL)] (4.4.7.1.1.7-5) In the equation, q1 equals the bearing capacity of the upper layer assuming the upper layer is of infinite extent. In these cases, the lightly loaded stiffener can be more slender without concern for local buckling of the stiffener. 206 . 136 Anchor Design .... 532 Concrete Exposed to Sulfate Soils or Water .... .48. = 804.1 kip-ft 37.50 ksi Hwu=: 0.5(69.0)((1 m0)37.50 + (-1 1.14)) 2 : : 454.7 kips 1999/2000COMMENTARY C-115 Example - Web Splice (cont'd) CASE 2: For negative flexure: fcu(bot. 15 15 Base metal adjacent to details attached by full or partial penetration groove welds with a transition radius, R, regardless of the detail length: Groove welded AttachmentsTransversely Loadedcsd Fillet Welded Connections Fillet Welded AttachmentsLongitudinally ~oaded~.~ -With the end welds ground smooth (a) Transition radius 2 24 in. For footings on less competent rock, more detailed investigations and analyses should be used to account for the effects of weathering, the presence and condition of discontinuities, and other geologic factors. 184 TUBULAR PIERS .... Structural tees preferably shall have the web extending downward. SOIL on M#(. C-133 states that Fyis to be taken as the yield strength of the longitudinal stiffener. In load factor design, design strength is computed as the product of the nominal resistance and the appropriate performance factor. 477 MATERIALS .... Sizeandshape ....75 MinirnumArea . 500 General Methods and Equipment .... 1.3.1.1 Selecting favorable stream crossings should be considered in the preliminary route determination to minimize construction, maintenance, and replacement costs. 505 BellFootings .... The notations for dimension units include the following: nondii = nondiiensional; deg = degree. .406 BOLTS .... As stated above, fillers need not be 5/16 inch minimum. 104 Batterpile .... The web splice plates shall extend as near as practical for the full depth between flanges. 360 Adjustments to Tabulated Design Values ....360 Wet Service Factor, CM ....360 Load Duration Factor, CD .... 566 Carbon Steel .... Footings supported on massive, competent rock formations which are highly resistant to scour shall be placed directly on the cleaned rock surface. EMBEDMENT IN COHESIVE SOIL RETAINING COHESIVE SOIL FIGURE 5.6.2D Simplified Earth Pressure Distributions for Temporary Flexible Cantilevered Walls with Continuous Vertical Wall Elements Modified after Teng (1962) TABLE 5.6.2A General Notes and Legend Simplified Earth Pressure Distributions for Permanent and Temporary Flexible Cantilevered Walls with Discrete Vertical Wall Elements LEGEND: 7' b = Effective unit weight of soil 4 = Spacing between vertical wall elements (clc) S, s = Undrained shear strength of cohesive soil = Vertical element width = Shear strength of rock mass P, Pa = Passive resistance per vertical wall element p p' = Ground surface slope behind wall = Active earth pressure per vertical wall element = Ground surface slope in front of wall + for slope up from wall - for slope down from wall Ka = Active earth pressure coefficient; Refer to Figure 5.5.2A K, = Passive earth pressure coefficient; Refer to Figures 5.5.2C and 5.5.2D ' = Effective angle of soil friction Nmm (1) For temporary walls embedded in granular soil or rock, refer to Figure 5.6.2A to determine passive resistance and use diagrams on Figure 5.6.2C to determine active earth pressure of retained soil. Dry-cast concrete block durability in a freeze-thaw environment is potentially a significant problem, as evidenced by the recent experience of the Minnesota DOT. Although research has indicated that compact sections composed of these steels can reach the plastic moment, M,, it has not been demonstrated that these sections have adequate inelastic rotation capacity at M, to redistribute interior-pier moments to more lightly loaded positive-moment sections. OVERLOAD . .544 Materials ....544 Test 1 - 4 ag Flow of Mixed Epoxy Bonding Agent ....544 Test 2-Gel Time of Mixed Epoxy Bonding Agent . 427 Minimum Reinforcement .... Downspouts, where required, should be made of rigid corrosion-resistant material not less than 4 inches in least dimension and should be provided with cleanouts. 183 Bentpiers .... The cost of limiting foundation movements shall be compared to the cost of designing the superstructure so that it can tolerate larger movements, or of correcting the consequences of movements through maintenance, to determine minimum lifetime cost. 533 Placing Methods .... 659 MATERIALS .... 4.4.8.1.2 Footings on Broken or Jointed Rock The design of footings on broken or jointed rock must account for the condition and spacing of joints and other discontinuities.The ultimate bearing capacity of footings on broken or jointed rock may be estimated using the following relationship: Refer to Table 4.4.8.1.2A for values of N,. 132 HIGHWAY BRIDGES Figures 5.6.2C and 5.6.2D, or other suitable earth pressure distributions, may be used with the following restrictions: The ratio of overburden pressure to undrained shear strength (i.e., stability number N = yWc) must be < 3. 4.11.4.2.2 4.11.5 Structural Capacity The structural design of footings shall comply to the provisions given in Articles 4.4.11 and 8.16. 3.25.1.2 For transverse flooring the span shall be taken as the clear distance between stringers plus one-half the width of one stringer, but shall not exceed the clear span plus the floor thickness. As a minimum, the results of the load test(s) shall provide the load-deformation response at the butt of the shaft. 575 Camber .... ,149 Location of Potential Failure Surface for Internal Stability Design of MSE Walls ....I50 Default Values for the Pullout Friction Factor, F* .... Exploration logs shall include soil and rock strata descriptions, penetration resistance for soils (e.g., SPT or q,), and sample recovery and RQD for rock strata. 266 COVER PLATES .... End stay plates shall have the same minimum length as specified for end stay plates on main compression members, and intermediate stay plates shall have a minimum length of % of that specified for intermediate stay plates on main compression members. Table 10.48.2.1A is modified accordingly. Elastic Stress Analysis . 307 10.39.2 Lateral Distribution of Loads for Bending Moment . C10.51.7 Design of Flange to Web Welds This new LFD article on design of flange-to-web welds for box girders parallels the existing ASD Article 10.39.5. The same requirements should be applied to box girders designed by ASD or LFD. Where vertical displacements are small, horizontal displacements shall be limited to 2.0 inches or less (Moulton et al., 1985). The design shall be made either with reference to service loads and allowable stresses as provided in SERVICE LOAD DESIGN or, alternatively, with reference to load factors, and factored strength as provided in STRENGTH DESIGN. 574 Heat Curving Rolled Beams and Welded Girders ....574 Materials .... This shall be considered when determining RFcRand RFD. The supporting capacity of piles shall be determined by static analysis methods based on soil-structure interaction. The filler shall either be extended beyond the splice material and secured by additional bolts, or as an alternate to extending the filler, an equivalent number of bolts may be included in the connection. 9. Operations . 3.24.5.1.1 Case A-Reinforcement Perpendicular to TrafJic Each wheel on the element perpendicular to traffic shall be distributed over a width according to the following formula: The moment per foot of slab shall be (PIE) X footpounds, in which X is the distance in feet from load to point of support. 347 MinimumCover .... 230 231 Segmental Box Girders .... 380 Bearing Area Factor, Cb ....380 Bearing on Inclined Surfaces .... 328 Noncomposite Hybrid Sections.............................. The current reference in this article to Article 10.48.2.1 is changed to the more correct reference to Article 10.48.2. C10.49.5 Partially Braced Members with Singly Symmetric Sections The indicated revisions to this LFD article parallel the revisions to ASD Articles 10.34.4.2 and 10.34.5.5 (see the earlier discussion on the proposed revisions to Articles 10.34.4.2 and 10.34.5.5). 650 Sacked Concrete Riprap .... 78 4.6.1.7 Shafts Through Embankment Fill .... The Theory of Elastic Stability, 2nd Edition, McGrawHill Book Company, New York, pp. The depth of web in compression, D,, in composite sections subjected to negative bending may be taken as the depth of the web in compression of the composite section without summing the stresses from the various stages of loading. Transversereinorcement may be constructed of hoops or spiral steel. Anchored walls are applicable for temporary and permanent support of stable and unstable soil and rock masses. Note: Part of the camber loss is attributable to construction loads and will occur during construction of the 270 10.16.9.2 HIGHWAY BRIDGES with Article 10.3. Terminations of butt welds shall be ground smooth. As a result, it becomes more convenient and more correct to express the maximum strength in terms of stress. 292 Pins, Rollers, and Expansion Rockers .... Otherwise, the load transfer to soil as a function of displacement may be estimated in accordance with Article 4.6.5.5.1. The butt settlement (p,) of drilled shafts fully socketed into rock may be determined using the following which is modified to include elastic shortening of the shaft. 4.11.3.4.3 Settlements of Footings on Rock The magnitude of consolidation and secondary settlements in rock masses containing soft seams shall be estimated by applying procedures discussed in Article 4.11.3.4.2. 4.11.4 Safety Against Soil Failure 4.11.4.1 Bearing Capacity of Foundation Soils Several methods may be used to calculate ultimate bearing capacity of foundation soils. Load testing should be conducted whenever special site conditions or combinations of load are encountered, or when structures of special design or sensitivity (e.g., large bridges) are to be supported on drilled shaft foundations. Substructure .... 638 CONCRETE RAILING . 533 Equipment .... 4.12.3.3.1 Axial Loading of Piles Preference shall be given to a design process based upon static analyses in combination with either field monitoring during driving or load tests. Plug Welds: Fv= 12,400 psi for resistance to shear stresses only, where, Fv= allowable basic shear stress. 542 Class 5 W i r e Brushed or Scrubbed Finish . Steel modular systems shall not be used where the steel will be exposed to surface or subsurface water which is contaminated by acid mine drainage, other industrial pol- The settlement of wall foundation support systems shall be estimated using procedures described in Articles 4.4,4.5, or 4.6, or other generally accepted methods. 4.6.5.5.2 Shafts Socketed into Rock In estimating the displacementof rock-socketed drilled shafts, the resistance to deformation provided by overlying soil deposits may be ignored. 401 Steel Plates .... 30 EARTHQUAKES .... .175 Strength Requirement .... Elastic shortening of the shaft shall be estimated using the following relationship: 4.6.5.5.1.2 DIVISION 1. All Groups Not Applicable Not Applicable 27,000 38,000 Not Applicable 27,000 50,600 Not Applicable 46,000 20,000 27,000 27,000 38,000 26,700 29,900 32,200 41,400 50,600 46,000 20,000 27,000 27,000 38,000 55,000 49,000 20,000 27,000 27,000 38,000 55,000 49,000 Not Applicable Cb = 1.75 + 1.05 (M1/M2) + 0.3 (MI/M$ 5 2.3 where MI is the smaller andM2 the larger end moment in the unbraced segment of the beam; MIM2 is positive when the moments cause reverse curvature and negative when bent in single curvature. The factored downdrag loads shall be added to the factored vertical dead load applied to the deep foundation in the assessment of bearing capacity. Bearing Strength . 490 Inspection of Metal Shells . E HIGHWAY BRIDGES = ultimate strength of prestressing steel, = = = = = MPa (Articles 9.15 and 9.17) yield strength of non-prestressed conventional reinforcement in tension, MPa (Articles 9.19 and 9.20) yield strength of non-prestressed conventional reinforcement in compression, MPa (Article 9.19) yield point stress of prestressing steel, MPa (Article 9.15) friction loss stress reduction below the level of 0.70 at the point under consideration, MPa (Article 9.16.2.1.4) overall depth of member, mm (Article 9.20) = moment of inertia about the centroid of the cross section, mm4 (Article 9.20) = friction wobble coefficient per unit length of prestressing steel, mm" (Article 9.16) = distance from end of prestressing strand to center of panel, mm (Article 9.17.4.2) = length of pmtmsing steel element from jack end to point x, mm (Article 9.16) = moment causing flexural cracking at section due to externally applied loads, N-mm (Article 9.20) = min steel cracking moment, N-mm (Article 9.18) = composite dead load moment at the section, N-mm (Commentary to Article 9.18) = noncomposite dead load moment at the section, N-mm (Article 9.18) = maximum factored moment at section = = = = = due to externally applied loads, N-mm (Article 9.20) nominal moment strength of a section, N-mm factored moment at section St$M, , N-mm (Articles 9.17 and 9.18) A,/bd, ratio of non-prestressed tension reinforcement, nondimensional (Articles 9.7 and 9.17-9.19) ratio of prestressing steel, AZM, indi dimensional (Articles 9.17 and 9.19) A~M, ratio of compression reinforcement, nondimensional (Article SH s % SC t extreme fiber of section where the tensile s a s s is caused by externally applied loads, mm3 (Article 9.18) = composite section modulus for the extreme fiber of section where the tensile stress is caused by externally applied loads, mm3 (Article 9.18) = average thickness of the flange of a flanged member, mm (Articles 9.17 and TO 9.18) = steel stress at jacking end, MPa (Article 9.16) Tx = steel stress at any point x, MPa (Article v = permissible horizontal shear stress, MPa (Article 9.20) = nominal shear strength provided by concrete, N (Article 9.20) = nominal shear strength provided by concrete when diagonal cracking results from combined shear and moment, N (Article 9.20) = nominal shear strength provided by concrete when diagonal cracking results from excessive principal tensile stress in web, N (Article 9.20) = shear force at section due to unfactored dead load, N (Article 9.20) = factored shear force at section due to externally applied loads occuning simultaneously with M, , N (Article 9.16) vc V* VW vd Vi vnb 9.20) = nominal horizontal shear strength, N (Article 9.20) w = vertical component of effective prestress force at section, N (Article 9.20) = nominal shear stffngth provided by shear reinforcement, N (Article 9.20) = factored shear force at section, N (Article 9.20) = mass density of concrete, kg/m3 (Article yt 9.16.2.1.2) = distance from centroidal axis of gross v~ vs vu section, neglecting reinforcement, to extreme fiber in tension, mm (Article 9.19) = factored tendon force, N = statical moment of cross sectional area, above or below the level being investigated for shear, about the centroid, mm3 (Article 9.20) = loss of prestress due to concrete shrinkage, MPa (Article 9.16) = longitudinal spacing of the web

reinforcement, mm (Article 9.20) = noncomposite section modulus for the 9.20) Cc = friction curvature coefficient, nondimensional (Article 9.16) APP. .383 Corrosion Protection .... 10.20 DIAPHRAGMS AND CROSS FRAMES 10.20.1 General Rolled beam and plate girder spans shall be provided with cross frames or diaphragms at each support and with intermediate cross frames or diaphragms placed in all bays and spaced at intervals not to exceed 25 feet. 229 Torsion . 67 . 10.29.5 Masonry Bearings Beams, girders, or trusses on masonry shall be so supported that the bottom chords or flanges will be above the bridge seat, preferably not less than 6 inches. 627 Material Friction Test (Sliding Surfaces Only) ....628 Dimensional Check .... Prestressing . FOR M I N E W Y S I S . 331 SPLICES, CONNECTIONS, AND DETAILS . In general, the width of a bent at its base shall be not less than one-third of its height. Shih. Tapered 9 a At End of Weld. Bronze Sliding Surfaces . (Where significant embedment of the wall is required to prevent bottom heave, the lowest section of wall below the lowest row of anchors must be designed to resist the moment induced by the pressure acting between the lowest row of anchors and the base of the exposed wall, and the force Pb = 0.7γ(Hb - 1.4cH - PCB,) acting at the midheight of the embedded depth of the wall.) The required embedment depth (d or Do) may be determined in accordance with Article 5.6.2. The procedure for anchored wall design depends on the number of anchor rows and the construction sequence. Payment . The location of the resultant center of pressure shall be as stated in Article 5.5.5. Provided the resultant location meets this criteria, an overturning stability analysis is not necessary. .348 General .... 326 SECTION 1 I C T E R I. STRUCTURES Table 1 1.4.3.3.2 Table 11.5A Table 1 1.5B Table 11.5C Minimum Cold-Bending Radii .... 571 Required Fastener Tension Minimum Bolt Tension inpounds ....578 Nut Rotation from the Snug-Tight Condition Geometry of Outer Faces of Bolted Parts ....579 Untitled .... 1347-1356 . 563 Temperature Considerations .... 10.23.1.2 Welding symbols shall conform with the latest edition of the American Welding Society Publication AWS A2.4 10.23.1.3 Fabrication shall conform to Article 11.4-Division II. 136 HIGHWAY BRIDGES For walls with multiple anchor levels a rectangular pressure distribution derived by increasing the total force from the triangular pressure distribution described above by one-third and applying the force as a uniform pressure distribution . 21 . 505 Load Tests .... CULVERT LOCATION, LENGTH, AND WATERWAY OPENINGS . 554 Strand . Structural continuity in the rail members, including anchorage of ends, is essential. 1-541. 4.11.1.3 Scour Protection Footings supported on soil or degradable rock strata shall be embedded below the maximum computed scour depth or protected with a scour counter-measure. 69 Friction Piles .... 402.9 SECTION 15.43 TEEL TUNNEL LINER PLATES 15.1 15.1.1 GENERAL AND NOTATIONS .... 457 DESIGN FORCES FOR SEISMIC PERFORMANCE CATEGORY A . PC, shall be taken equal to design stress, Fcv, times the smaller effective flange area, Ae, on either side of the splice. Rigid frames shall be designed for unfactored differential settlements based on the results of special analyses. Accordingly, the word 'compressive' is removed from in front of the words 'concrete stress' in the paragraph following the definitions of G and f. The side resistance provided by soft or weathered rock should be neglected in determining the required socket length where a socket extends into more competent underlying rock. -4 BlastProtection .... 4 SUPERELEVATION .... The total length of reinforcement required for pullout is equal to La La as shown in Figure 5.8.5.1A. If bars are bundled in forming the reinforcing cage, the minimum clear distance between longitudinal reinforcement shall 4.6.5.6.7 not be less than 3 times the diameter of the bundled bars. Apparatus for measuring loads. III,No. 6, June 1985, pp. The ratio of the net width (through the pin hole transverse to the axis of the member) to the thickness of the segment shall not be more than 8. Supplementary material requirements should provide guarantee that material will meet these values. 435 Ribbed PVC pipe requirements .... This equation does not indicate an overall web slenderness limit for braced noncompact sections, but it simply is the slenderness limit below which local web bend-buckling theoretically does not occur. 10.18.2.1.4 In both flange and web splices, highstrength bolted connections shall be proportioned to prevent slip during erection of the steel and during the casting or placing of the deck. 5.8.5 Determination of Reinforcement Length Required for Internal Stability 5.8.5.1 Location of Zone of Maximum Stress The location of the zone of maximum stress for inextensible and extensible wall systems, which forms the boundary between the active and resistant zones, is determined as shown in Figure 5.8.5.1A. .95 Performance Factors for Geotechnical Strength Limit States in Axially Loaded Drilled Shafts .... 347 ... 573 General .... The soil parameters used in the analyses shall be chosen to reflect the loading history of the ground, the construction sequence and the effect of soil layering. In addition to general bearing capacity, settlement, and stability considerations, the minimum embedment required shall consider the potential for local bearing capacity failure under the leveling pad or footing due to higher vertical stresses transmitted by the facing. 205 Biaxial Loading .... 205 Hollow Rectangular Compression Members .... The terminal distance is two times the nominal cover plate width for cover plates whose ends are not welded, and 1½ times for cover plates welded across their ends. ix. lxxvi CONTENTS lxxviii C SECTION 5-RANALYSIS REQUIREMENTS Figure 4.4A Figure C4.4A Figure 4.4B Figure C4.4B Figure C4.5.2 Bridge Deck Subjected to Assumed Transverse and Longitudinal Loading ....455 Plan View of a Bridge Subjected to a Transverse Earthquake Motion ....C-54 Bridge Deck Subjected to Equivalent Transverse and Longitudinal Seismic Loading ....455 Displacement Function Describing the Transverse Position of the Bridge Deck ....C-55 Deflected Shape Due to Uniform Static Loading ....C-56 Characteristic Static Loading Applied to the Bridge System ....C-56 Iterative Procedure for Including Abutment Soil Effects in the Seismic Analysis of Bridges ....C-57 SECTION 7-DESIGN REQUIREMENTS FOR BRIDGES IN SEISMIC PERFORMANCE CATEGORIES C AND D Figure C7.2.2A Figure C7.6.2A Figure C7.6.2B Figure C7.6.2C Figure C7.6.2D Development of Approximate Overstrength Interaction Curves from Nominal Strength Curves (after Gajer and Wagh) ....C-69 Confining Pressure Provided by a Spirally Reinforced Column ....C-69 Confining Pressure Provided by a Rectangular . 68 Materials .... 307 10.39.1 General . The reinforcement strength required shall be checked at every level within the wall for ultimate limit state. 4.6.5.5.1.2 Cohesionless Soil The short-term settlement of shafts in cohesionless soil may be estimated using Figures 4.6.5.5.1.2A and 4.6.5.5.1.2B. All welds connecting cover plates to flanges shall be continuous and shall not be smaller than the minimum size permitted by Article 10.23.2. 10.13.5 DIVISION I-DESIGN - - - 267 -- 10.13.5 Any partial length end-bolted cover plate shall extend beyond the theoretical end by a terminal distance equal to the length of the end-bolted portion, and the cover plate shall extend to a section where the stress range in the beam flange is equal to the allowable fatigue stress range for base metal at ends of partial length welded cover plates with high-strength bolted, slip-critical end connections (Table 10.3.1B). Y-Y axis, mm (Article 10.48.1.1) = radius of gyration of the compression flange about the axis in the plane of the web, mm (Table 10.32.1A, Article 10.48.4.1) = allowable rivet or bolt unit stress in shear, MPa (Article 10.32.3.3.4) = section modulus, mm3(Articles 10.48.2, 10.51.1, 10.53.1.2, and 10.53.1.3) = pitch of any two successive holes in the chain, mm (Article 10.16.14.2) = diaphragm . For structural design of an eccentrically loaded foundation, a triangular or trapezoidal contact pressure distribution based on factored loads shall be used. MPa (Articles 10.32.3.3 and 10.56.1.3.2) = unit shear stress, MPa (Articles 10.32.3.2.3 and 10.34.4.4) = computed compressive bending stress about the x axis, MPa (Article 10.36) = gage between fasteners, mm (Articles 10.16.14 and 10.24.5) = height of stud, mm (Article 10.38.5.1.1) = average flange thickness of the channel flange, mm (Article 10.38.5.1.2) = moment of inertia, mm4(Articles 10.34.4.5, 10.38.5.1.1, 10.48.5.3, and 10.48.6.3) = moment of inertia of stiffener, mm4 (Articles 10.37.2, 10.39.4.4.1, and 10.51.5.4) = inertia of transverse stiffeners, mm4 (Article 10.39.4.4.2) vertical axis in the plane of the web, mm4 (Article 10.48.4.1) = moment of inertia of compression flange about the vertical axis in the plane of the web, mm' (Table 10.32.1A. Note that T, should not be greater than T,. > Transition radius 2 0 in. 88 . The formulas do not apply to members with variable moment of inertia. 3.25.1 Transverse Flooring 3.25.1.1 In the direction of flooring span, the wheel load shall be distributed over the width of tire as given in Article 3.30. =See Aside 10.32.3.4 for bolts subject to tensile fatigue. Where angles are used, either singly or in pairs, they preferably shall be placed with the vertical legs extending downward. Tolerable settlement criteria for foundations shall be developed considering the maximum angular distortion according to Article 4.4.7.2.3 or 4.4.7.2.3. Tolerable horizontal displacement criteria shall be developed considering the potential effects of combined vertical and horizontal movement. 10.16.14.5 When determining the unit stress on any least net width of either splice material or member being spliced, the amount of the stress previously transferred by fasteners adjacent to the section being investigated shall be assumed. 351 351 Standard Shell End Types .... At butt-welded splices joining pieces of different thicknesses, there shall be a uniform slope between the offset surfaces, including the weld, of not more than 1 in 2½. 70% strength retained after 500 hrs in W Oxidation Resistance ASTM D 4355 weatherometer Min. Ductile Iron Castings. 232 Temporary Stresses Before Losses Due to Creep and Shrinkage .... Footings on soil shall be designed so that the eccentricity of loading is less than ⅙ of the footing dimension in any direction. Analysis of drilled shafts subjected to combined loading may be conducted using the COM624 analysis (Reese, 1984). IO' 4.13.3.3.1 Axial Loading of Drilled Shafts .... 33 Design Considerations . 583 11.6.1 General .... a., ShOrt-sloted holes loaded in any direction, or O.SIP. 43 FOUNDATION TYPE AND CAPACITY .... In compression members the pitch of stitch fasteners on any single line in the direction of stress shall not exceed 12t,except that, if the fasteners on adjacent lines are staggered and the gage, g, between the line under consideration and the farther adjacent line (if there are more than two lines) is less than 24t, the staggered pitch in the two lines, considered together, shall not exceed 12t or 15t - 3g/8. The capacity of each anchor shall be verified as part of a stressing and testing program. 26 26 Group 11and Group V Loadings .... Bracket or shelf angles which may be used to furnish support during erection shall not be considered in determining the number of fasteners required to transmit end shear. 390 FPTE Sliding Surfaces .... Reference to Grade HPS70W steel has been added. 69I B ~ e k ~ Sion Loadings .... 517 Structure Excavation .... 556 Placement of Ducts .... The following items specified in that article shall also apply to concrete filled steel grid floors: Longitudinal edge beams Unsupported transverse edges Span lengths 3.27.2.2 The strength of the composite steel and concrete slab shall be determined by means of the "transformed area" method. 10.10 OUTSTANDING LEGS OF ANGLES 10.13.3 The maximum thickness of a single cover plate on a flange shall not be greater than two times the thickness of the flange to which the cover plate is attached. 620 18.4.6.1 Bronze .... 615 MATERIALS ....615 Wood ....615 Preservatives and Treatments .... Furthermore, product specific test data shall be provided which can be extrapolated to the intended design life and which proves that the product will be capable of performing as intended in an exposed environment. 4.12.3.3.10 Group Capacity 4.12.3.3.10~ Cohesive Soil If the cap is not in firm contact with the ground, and if the soil at the surface is soft, the individual capacity of Iert \ (footing (b) \ FIGURE C4.12.3.3.2-1 Location of Equivalent Footing (After Duncan and Buchignani, 1976) FIGURE C4.12.3.3.4-1 Bearing capacity coefficient, K, (After Canadian Foundation Engineering Manual, 1985) As referenced in Section 4 in Article 4.12.3.3.7b and 4.13.2, the following figures have been reprinted from the 1993 Commentary of the 1993 Interim to the Standard Specifications for Highway Bridges. The stress induced shall be computed in accordance with Article 10.20.2.1. The allowable stresses shall be determined in accordance with Article 3.22. 679 Latex Modified Concrete .... 680 Surface Preparation .... Where curbed roadway sections approach a structure, the same section shall be carried across the structure. WORKING DRAWINGS . Also, the horizontal shear force in the deck is most often considered to be effective along the entire span in the analysis. 10.9 EFFECTIVE AREA OF ANGLES AND TEE SECTIONS IN TENSION 10.9.1 The effective area of a single angle tension member, a tee section tension member, or each angle of a double 266 HIGHWAY BRIDGES angle tension member in which the shelf angles are connected back to back on the same side of a gusset plate shall be assumed as the net area of the connected leg or flange plus one-half of the area of the outstanding leg. For continuous reinforcement layers, b 5 1 and R = 1. For a typical wall with two or more rows of anchors constructed from the top down, the procedure requires design for the final structure with multiple rows of anchors and checking the design for the various stages of wall construction. 105 4.13.1 General .... 397 Combined Corn ression and Rotation .... The flanges and stems of stemmed or channel sections are considered as separate rectangular components whose values are summed together to calculate ~ . 272 Fillers . 245 DesignoftheLocalZone . 3.26 DISTRIBUTION OF WHEEL LOADS AND DESIGN OF COMPOSITE WOODCONCRETE MEMBERS 3.26.1 Distribution of Concentrated Loads for Bending Moment and Shear 3.26.1.1 For freely supported or continuous slab spans of composite wood-concrete construction, as described in Article 16.3.14, Division II, the wheel loads Span Maximum Live Maximum uniform Dead Load Moments Load Moma~is Wood Composite Concentrated Uniform Subdeck Slab load Load Pas. 358 358 General .... 329 COMPRESSION MEMBERS .... 330 AxialLoading . -122 Procedure to Determine Lateral Pressure Due to Point and Line Loads, Modified after Terzaghi (1954) .... 610 Countersinking . segmental concrete facing blocks) ~may be desirable t~ exclude the facing elements and weight in sliding end overturning calculations (1,0 . 4.4.7.1 . and Alternatives ....653 Reinforcing Steel .... However, since the Federal Highway Administration and the States have established a goal that the LRFD standards be used on all new bridge designs after 2007, only edits related to technical errors in the specifications were made in the interim revisions of the seventeenth edition will be made hereafter. 574 General .... **These test procedures are in draft form. Reference to the use of the maximum subpanel depth in designing transverse stiffeners on longitudinally stiff- C-121 ened girders is eliminated in the definition of D in Equation (10-123) for consistency with the revision to Article 10.34.5.6 discussed below. 497 Piles Driven .... 497 Pile Splices, Pile Shoes, and Pile Lugs .... 497 Load Tests .... 10.32.3.3.2 Bolts required to support applied load by means of direct tension shall be so proportioned that their average tensile stress computed on the basis of nominal bolt area will not exceed the appropriate stress in Table 10.32.3B. AND RESISTANCE FACTORS . 4.10 LIMIT STATES, LOAD FACTORS, AND RESISTANCE FACTORS 4.10.1 General All relevant limit states shall be considered in the design to ensure an adequate degree of safety and serviceability. 419 DIVISION I-A SEISMIC DESIGN SECTION 3-GENERAL REQUIREMENTS - Table 3.4 Table 3.5.1 Table 3.7 Seismic Performance Category (SPC) .... 432 Buckling .... 5.5.5 Structure Dimensions and External Stability Gravity and semi-gravity walls shall be dimensioned to ensure stability against possible failure modes by satisfying the following factor of safety (FS) criteria: Sliding - FS ≥ 1.5 Overturning FS ≥ 2.0 for footings on soil FS ≥ 1.5 for footings on rock Bearing Capacity for Static Loading See Article 4.4.7 for footings on soil See Article 4.4.8 for footings on rock The factors of safety against sliding and overturning failure under seismic loading may be reduced to 75% of the factors of safety listed above. N (Articles 10.32.3.3.2 and 10.56.2) = statical moment of area about the neutral q axis, mm3 (Article 10.38.5.1.1) R & Rev R, R,, R,, r rb T V r' S S S sd sr ss st su s, s T AFP- E = radius, mm (Article 10.15.2.1) = number of shear connectors in a beam between points of maximum positive moment and adjacent end support (Article 10.38.5.1.2) = Q-D, ratio: (Articles 10.40.2.1.1, 10.53.1.2, and 10.53.1.3) = bending capacity reduction factor. 183 Double Wall Piers .... 5.8.4.2 Determination of Reinforcement Tensile Load at the Connection to the Wall Face The tensile load applied to the soil reinforcement connection at the wall face, To, shall be equal to To , at the level 2 ALL STRESSES IN KSI .... Also, language has been added at the end of footnote d in order to clarify the definition of the 50-inch length used in determining whether or not to apply the joint-length correction factor when calculating the shear strength of high-strength bolts in flange splices. The allowable reference stress is determined by multiplying the allowable stress by the cross-sectional area of the steel reinforcement in the connection across losses. 410 . Surface Under Bearings .... (See Frank and Fisher, Journal of the Structural Division, ASCE, Vol. Instead, the table refers to the applicable Dit, limits specified in the referenced articles. 2 8) WALL FACE BATTER ALL ANGLES ARE POSI T I VE (+) AS SHOWN FIGURE 5.5.2A Computational Procedures for Active Earth Pressures (Coulomb Analysis) 5.5.2 (123 DIVISION I-DESIGN Line LordOl, Point Load Qp U ' ~ 4 wall tp - V ~ O 'l'S ~ ~ ~ . 77 Unfilled Tubular Steel Piles . 314 10.41.3.1 314 10.41.3.2 Girders .... The coefficient of active earth pressure, Kd used to compute the horizontal force resulting from the retained backfill behind the reinforced zone and other loads shall be computed on the basis of the friction angle of the retained backfill. 69 Combination Friction and End Bearing Piles .... 670 . .539 . 197 Bearingstress .... 660 Box Culverts .... Water. In the past, Interim Specifications were usually published in the middle of the calendar year, and a revised edition of this book was generally published every 4 years. REFERENCES 1. McMinn, Raymond and Ashland G. 664 "V" Shaped Bed (Foundation) for Larger Pipe Arch, Horizontal Ellipse and Underpass Structures ....665 End Treatment of Skewed Flexible Culvert .... 666 SECTION 27-CONCRETE CULVERTS Figure 27.5A Figure 27.5B Figure 27.5C Standard Embankment Installations .... 10.24.3.5 Where ASTM A 307 bolts are used, a minimum of 2% shall be used. A 490 bolts equal to or less than 1 inch in diameter are to be installed in an oversize or short slotted hole in an outer ply, a hardened washer conforming to ASTM F 436 shall be used. 20 Classes of Loading .... -21 Designation of Loadings .... 265 Temperature Zone Designations for Charpy V-Notch Impact Requirements . 4.3.4 Failure by Sliding Failure by sliding shall be investigated for footings that support inclined loads and/or are founded on slopes. local conditions. Clearances . External loads such as surcharges will increase the minimum reinforcement length. 559 Polyethylene Duct .... 559 DuctFittings ....559 Portland Cement .... Beams with end-bolted cover plates shall be fabricated in the following sequence: drill holes; clean faying surfaces; install bolts; weld. In the indicated revision to this article, a new Equation (10-100) is given to specify the limiting compressionflange slenderness ratio. 267 Scope .... f r o n t t o bck trn) distancr to- the center o f grevrtg o f a horizontal segmental facing block unit. 70 Axial Capacity in Cohesive Soils .... 104 Cohesionless Soil .... 638 638 TEMPORARY RAILING .... 259 Charpy V-Notch Impact Requirements ....259 Shear .... 659 EFFECTIVE LENGTH OF SPAN .... The time (t) to achieve a given percentage of the total estimated 1-D consolidation settlement may be estimated using the following: Refer to Figure 4.4.7.2.3b for values of T for constant and linearly varying excess pressure distributions. Deep Foundation-A foundation which derives its support by transferring loads to soil or rock at some depth below the structure by end bearing, by adhesion or friction or both. Timber Connectors ....608 Dimensions . The plates shall be not less than 4 feet wide and shall be cast-iron, a corrosion and blast-resisting alloy, or asbestos-board shields, so supported that they may be readily replaced. Continuous nail laminated floor and interconnected nail laminated floor, with adequate shear transfer between panels*, not less than 6 inches thick: width of tire plus twice thickness of floor. Equation 5.6.6-2 is applicable for simply supported facing behind which the soil will arch between vertical supports (e.g., in granular or stiff cohesive soils with flexible facing or rigid facing behind which there is sufficient space to permit the in-place soil to arch). Use the lower of (Ton + a t the base of the wall or Tamp a t the t h e l o w e s t r e i n f o r c e m e n t layer for continuous reinforcements. Except for the mandatory mtch toughness and weldability requirements, the AShvt designations are similar to the AASHTO designations. If a normal level of field quality control cannot be assured, higher minimum factors of safety shall be used. The control measurements should be undertaken in the form of random samples. 341 LOAD FACTOR DESIGN .... -342 Walldesa . For girders, the stiffener spacing shall not exceed the maximum value specified in Article 13.2.1. If timber is used where conditions are favorable for the growth of decay-producing organisms, wood should be pressure treated with a wood preservative unless the heartwood of a naturally decay-resistant species is available and is con- 5.6.8 Corrosion Protection Refer to Article 5.7.8. 5.7 ANCHORED WALL DESIGN 5.7.1 Design Terminology Refer to Figure 5.7.1A for terminology used for the design of anchored retaining walls. 492 Followers .... 10.18.1.3 Design Force for Flange Splice Plates For a flange splice with inner and outer splice plates, the flange design force may be assumed to be divided equally to the inner and outer plates and their connections when the areas of the inner and outer plates do not differ by more than 10%. The environment at the face, in addition to within the wall backfill, shall be evaluated, especially if the stability of the facing is dependent on the strength of the geosynthetic at the face, i.e., the geosynthetic reinforcement forms the primary connection between the body of the wall and the facing. 216 xxv xxvi CONTENTS Minimum Shear Reinforcement ....216 Types of Shear Reinforcement .... 356 Rh,Haunch Moment Reduction Values ....356 SECTION 13-WOOD STRUCTURES Table 13.2.1A Table 13.2.2A Table 13.5.1A Table 13.5.1B Table 13.5.2A Table 13.5.3A Table 13.5.3B Table 13.5.4A Table 13.5.4B Table 13.5.5A Table 13.6.1A Table 13.7.1A Net Dry Dimensions for Dressed Lumber ....358 Standard Net Finished Widths of Glue Laminated Timber Manufactured from Western Species or Southern Pine ...359 Tabulated Design Values for Visually Graded Lumber and Timbers .... Y BRIDGES In keeping with the current convention of expressing the maximum bending strength of braced noncompact sections in terms of a moment capacity, it is implicitly inferred that the provisions of this article should only be applied to braced noncompact noncomposite sections. .481 . However, when precast decks are used with the stud shear connectors clustered in pockets several feet apart, the Engineer may wish to limit the maximum bending strength of the top (compression) flange according to Equation (10-99) in Article 10.48.2 and check the limiting blt ratio specified in Article 10.48.2.1(a) in order to ensure that local buckling of the flange will not occur in the regions between the shear connectors. 511 CreepTest .... The negative-moment region of a continuous span is often implicitly taken as the region between points of dead-load contraflexure, but under moving live loads, the concrete deck can experience sigmficant tensile stresses outside the points of dead-load contraflexure. Bearing capacity a. 2.7.3 Pedestrian Railing 2.7.2.2.5 Posts shall be designed for a transverse load of wL (where L is the post spacing) acting at the cen- 2.7.3.1.1 Railing components shall be proportioned commensurate with the type and volume of anticipated 2.7.3.1 General (To be used adjacent to a sidewalk when highway traffic is separated from pedestrian traffic by a traffic railing.) PEDESTRIAN RAILING surface BICYCLE RAILING If screening or solid face is presented, number of rails may be reduced; wind loads must be added if solid face is utilized. Drainage panels shall maintain their drainage characteristics under the design earth pressures and surcharge loadings, and shall extend from the base of the wall to a level 1 foot below the top of the wall. Rigid gravity and semi-gravity walls are generally used for permanent wall applications.These types of walls can be effective for both cut and fill wall applications due to their relatively narrow base widths which allows excavation laterally to be kept to a minimum. .380 . AASHTO M 270 (ASTM A 709) Grade HPS70W steels have been tested by the New York State Thruway Authority (NYSTA) up to 1245°F.Acopy of the report of the work done by High Steel Structures for NYSTA is available from FHWA. These 81s limits shall not be applicable to rigid frame structures. 245 Bursting Forces ....245 Edge-Tension Forces .... Short, continuous span bridges, particularly overpasses, may be built without inlets and the water from the bridge roadway carried downslope by open or closed chutes near the end of the bridge structure. The fasteners connecting each member shall be symmetrical with the axis of the member, so far as practicable, and the full development of the elements of the member shall be given consideration. .;...............538 Striking Off and Floating ....538 538 Straightedging .... Both total and differential settlements, including time effects, shall be considered. .489 Concrete Pies .... 541 Class %Rubbed Finish .... The upright stems or 5.5.6.2 DIVISION I-DESIGN 127 DESIGN FACTOH OEFlNlTlOnS v KIWT OF WLL r ~ S) OI L W ~ O ~TPE F m ua ~EMIO~VITY w a s . 527 Responsibility and Criteria ....527 Trial Batch Tests .... FORKED ENDS .... 228 Prestressing Steel ....228 Non-Prestressed Reinforcement ....228 PART B-ANALYSIS GENERAL . The use of presumptive values shall be based on the results of subsurface exploration to identify soil and rock conditions. mm Minimum Size of Fillet in. 4.6.6.2.1 Longitudinal Bar Spacing The minimum clear distance between longitudinal reinforcement shall not be less than 3 times the bar diameter nor 3 times the maximum aggregate size. .3. To reduce this significant inherent conservatism in the ASD constructibility check and make it more equivalent to the LFD check (for reasons discussed previously under the Commentary to the revision to Article 10.34.2.1.5), the current ASD equation for the lateral-torsional buckling capacity in Table 10.32.1A should be multiplied by 1.4 when making this check. 409 . 5 FLOOR SURFACES ....5 UTILITIES ....5 SECTION 2.. 627 CORROSION PROTECTION .... unit ww *wA -WB=\~,Include a11 u n r u tkot or0 ateckod over th. RFIDand RFDshall not be less than 1.1. sile stress may be increased by 40 %. 504 DrilledShaft .... 677 Backfill ....677 Placing of Haunch. Language similar to the language in the existing paragraph at the end ofArticle 10.48.4.1, which r e f e r e d to footnote b, has been inserted in Articles 10.48.5.1 and 10.49.2 instead. If other units are used, the dimensional correctness of the equations shall be confirmed. 10.23.3 DIVISION I-DESIGN Base Metal Thickness of Thicker Part Jointed (T) in. The value of q,,, obtained using the reduced footing dimensions represents an equivalent uniform bearing pressure and not the actual contact pressure distribution beneath the footing. 300 10.36 COMBINEDSTRESSES . .352 . .396 Load Deflection Behavior of Elastomeric Bearings ....C.21 Elastomeric Bearing-Interaction Between Compressive Stress and Rotation Angle .... .I01 lxxiv lxxv CONTENTS Tables SECTION 5-RETAINING WALLS Table 5.5.2A Table 5.5.2B Table 5.6.2A Table 5.7.6.2A Table 5.7.6.2B Table 5.8.5.2A Table 5.8.6.1.2A Table 5.8.6.1.2B Table 5.8.7.2A Relationship Between Soil Backfill Type and Wall Rotation to Mobilize Active and Passive Earth Pressures Behind Rigid Retaining Walls . 27 Forces from Superstructure .... 641 Special Details ....641 Damage Patching .... .537 . Contact the Geosynthetic Research Institute, Drexel University in Philadelphia, PA. 400 . 236 Rectangular Sections .... The current cell class number for the ESCR is "2." This number should be changed to "0" if the SP-NCTL test is adöpted by the AASHTO Subcommittee on Materials in August 2000. The performance factors for uplift capacity of groups of drilled shafts shall be the same as those for pile groups as given in Table 4.10.6-3. (10 - 4k) (10 - 41) where: F, = design stress for the controlling flange at the point of splice defined in Article 10.18.2.2.1 (positive for tension; negative for compression) R = reduction factor for hybrid girders specified in Article 10.53.1.2. R shall be taken equal to 1.0 when fcuis less than or equal to F, where F, is equal to the specified minimum yield strength of the web. Scour . Disc Bearings . 625 . 537 Sealed Joints .... Future revisions will have the same status as standards of the American Association of State Highway and Transportation Officials (AASHTO) and are approved by at least two-thirds of the Subcommittee on Bridges and Structures. Such an assumption was also made in the development of the new wheel-load distribution factors given in an AASHTO Guide Specification. 477 DepthofFootings ....477 Foundation Preparation and Control of Water . 9 All reduction factors shall be based on product specific data. 341 Construction and Installation .... 623 FABRICATION .... E HIGHWAY BRIDGES a = total angular change of prestresskg steelprofile from jacking end to point x, 81 = factor for concrete strength, as defined in * = factor for type of prestressing steel radians (Article 9.16) 7 Article 8.16.2.7 (Articles 9.17-9.19) (Article 9.17) = 0.28 for low-relaxation steel = 0.40 for stress-relieved steel = 0.55 for bars 745 746 HIGHWAY BRIDGES APP.E APP. .334 SECTION 1243OIL-CORRUGATED METAL STRUCTURE INTERACTION SYSTEMS Table 12.7.2A Table 12.8.2A Table 12.8.4A Table 12.8.4B Table 12.8.4C Minimum Requirements for Long-Span Structures with Acceptable Special Features ....348 Geometric Requirements for Box Culverts . For combination railings, accommodating pedestrian or bicycle traffic, the maximum opening between railing members shall be governed by Articles 2.7.2.2.2 and 2.7.3.2.1, respectively. T r e f f l c Ltve Load 'Tenp 1s f o r contrnuour r o l l reinforcements (0.9.. The performance factor for the uplift capacity of drilled shafts shall be as provided in Table 4.10.6-3. 4.11.1.6 Groundwater 4.11.1.8 Deterioration Footings shall be designed for the highest anticipated position of the groundwater table. SlMPLI FlED DESIGN PROCEDURE VWITIChL WhU FIGURE 5.6.2B Simplified Earth Pressure Distributions and Design Procedures for Permanent Flexible Cantilevered Walls with Continuous Vertical Wall Elements Modified after Teng (1962) COHESIVE SO1 L (&.'I NOTE FOR SLOPING BACKFILL USE EFFECTIVE SHEAR STRENGrti PARAMETERS (C - 0) AND FIGURE 5.6.2.C.o FINISHED GRADE a EMBEDMENT IN COHESIVE SOIL RETAINING GRANULAR SOIL b EM0EDMENT I N COHESIVE SOIL RETAINING COHESIVE SOIL NOTE1 REFER TO TABLE 5.6.2A FOR GENERAL NOTES AND LEGEND FIGURE 5.6.2C Simplified Earth Pressure Distributions for Temporary Flexible Cantilevered Walls with Discrete Vertical Wall Elements 5.6.2 DIVISION I-DESIGN 131 -- GRANULAR \ SOlL I [~su, i* COHESIVE SOIL 2 COHESIVE SOIL (7; 1 su21 a. 108 4.13.3.3.6 Uplift Capacity .... 231 .-. Development of passive earth pressure in the soil in front of a rigid wall requires an outward rotation of the wall about its toe or other movement of the wall into the soil. General .... 657 Forming and Punching of Steel Liner Plates ....657 INSTALLATION ....658 Steel Liner Plates .... Concrete Monolithic Cell Members .... 49 4.4.7 49 4.4.7.1 Bearing Capacity .... 645 Description .... Loadings on left are applied to rails. 300 10.35.2 Compression Members-Thickness of Metal .... (1961), "Strength and Design of Metal Beam-Columns," Journal of the Structural Division, ASCII, Vol. 587 MATERIALS ....587 Steel .... Where rock strata within this interval are variable in strength, the rock with the lowest capacity I f ROO is fairly uniform, use average ROO within d a 8 I f ROO within d = 814 i s lower, use lower ROO R O O (Ye) Note: Qallsha l l not exceed the unwnf ined compressive strength af the rock or 0.595 f 'c of the concrete. C10.53.1 Noncomposite Hybrid Sections The word 'girders' is replaced with the more appropriate word 'sections' in the heading for this article. 104.1 'Qpical Mechanically Stabilized Earth Gravity Walls .... 610 Temporary Attachment ....610 Installation of Connectors .... 347 Steel Conduits .... 95 xvii Division I CONTENTS Single Pile Uplift Capacity .... .375 . (b) Estimated scour depth at piers and abutments of proposed structures. 199 Shear-Friction Design Method .... These multipliers are sufficiently accurate for the reinforcement types covered in Figure 5.8.4.1C. 509 Anchorage and Trumpet ....509 Tendon Storage and Handling ....509 INSTALLATION ....509 CONTENTS Drilling .... 604 Laying Block and Brick .... The downdrag loads shall be added to the vertical dead load applied to the deep foundation in the assessment of settlement at service limit states. Values for RFcRand RFD shall in general be determined from product specific test results. As an alternative to being below the depth of frost penetration, the soil below the wall but above the depth of frost penetration can be removed and replaced with nonfrost susceptible clean granular soil. 646 . Lateral and longitudinal restraint provided by bearings can also be considered to help provide restraint against both twist and lateral deflection. 651 SECTION 24-PNEUMATICALLY APPLIED MORTAR DESCRIPTION ....653 MATERIALS . 431 Soil Parameters ....431 Abrasive or Corrosive Conditions ....432 Minimum Spacing .... .471 General .... 161 5.8.9.1A. Side plates shall not be used except where flange angles exceeding 7/s inch in thickness otherwise would be required. 10.18.1.2.2 For bolted web splices with thickness differences of %6 inch or less, no filler plates are required. In addition, lower limits are placed on the bendbuckling coefficient k for a longitudinally stiffened girder for reasons discussed previously (see commentary on revisions to Article 10.34.3.2.1). ..... 312 10.40 General .... The performance factor is the same as those for single pile capacities as given in Table 4.10.6-2. E HIGHWAY BRIDGES 737 738 HIGHWAY BRIDGES APP.E ADD. 303 10.38.1 General . Piping-Progressive erosion of soil by seeping water, producing an open pipe through the soil, through which water flows in an uncontrolled and dangerous manner. Rating of older bridges with more than two longitudinal stiffeners becomes problematic if the current requirements are employed because the longitudinal stiffeners are not likely to provide enough moment of inertia to satisfy the unrealistically high requirement. 287 PART C-SERVICE LOAD DESIGN METHOD ALLOWABLE STRESS DESIGN 10.31 10.32 SCOPE .... 10.24.5.4 Maximum Spacing of Fasteners The maximum spacing of fasteners shall be in accordance with the provisions of Article 10.24.6, as applicable. 573 Annealing and Stress Relieving .... For permanent walls and for temporary walls in granular soils, the simplified earth pressure distributions shown in Figures 5.6.2A and 5.6.2B, or other suitable earth pressure distributions, may be used. IF. See Article 4.4.5 for procedures to determine the required embedment depth of wall foundations; Articles 4.4.7 and 4.4.8, respectively, for procedures to design spread footings on soil and rock; and Articles 4.5 and 4.6, respectively, for procedures to design pile and drilled shaft foundations. .285 . Lateral displacement of a structure shall be evaluated when: -horizontal or inclined loads are present, -the foundation is placed on an embankment slope, -possibility of loss of foundation support through erosion or scour exists, or -bearing strata are significantly inclined. Shear F 9 Base metal adjacent to details attached by fillet welds with length, L, in the direction of stress, is less than 2 in, and stud-type shear connectors. 279 Diaphragms and Cross Frames ....279 Stresses Due to W i d Load When Top Flanges Are Not Continuously Supported ....280 LATERAL BRACING .... in.-lb. 198 Shear in Compression Members . .527 .. C10.54 COMPRESSION MEMBERS C10.56.1.4 Slip-Critical Joints C10.54.1 Axial Loading C10.54.1.1 Maximum Capacity (Axial Load) A footnote to this article is added regarding the computation of the maximum capacity of concentrically loaded columns in LFD. : .... 493 493 Preboring to Facilitate Driving .... Overall Stability . Retaining walls for temporary applications are typically designed for a service life of 36 months or less. Performance factors for the uplift capacity of single piles shall be as provided in Table 4.10.6-2. .646 . Even with product specific test results, RFD and shall be no less than 1.1 each. .71 Figure 4.5.4A Design Terminology for Drilled Shaft Foundations .... Using the subpanel depth unnecessarily complicates the provision. 228 EXPANSION AND CONTRACTION .... Dampproofing . Consolidation and secondary settlement may be determined using the full unfactored dead load only. .259 Allowable Fatigue Stress Ranges ....259 Load Cycles .... .627 Tapered Sole Plates .... 394 SealingRings .... .115 Tolerable Deformations.................................. .- Distribution of Concentrated Load Effects to Bottom Slab ....425 Distribution of Concentrated Loads in Skewed Culverts ....425 Span Length .... Upto 4 in. 10.9.1 under Strength Design as specified in Articles 10.48.1, 10.50.1.l, and 10.50.2.1. When computing the strength of a flexural member at a section with holes in the tension flange, an effective flange area, &,specified by Equation (10-4g) shall be used for that flange in computing the elastic section properties. Bearing pressures shall be computed using the Meyerhof distribution, which considers a uniform base pressure distribution over an effective base width of B' = L - 2e, as shown in Figures 5.8.3A and 5.8.3B. 612 Nail Laminated or Strip Floors .... 4.12.3.2.3 Settlement The settlement of a pile foundation shall not exceed the tolerable settlement, as selected according to Article 4.12.3.2.2. 4.12.3.2.3~ Cohesive Soil Procedures used for shallow foundations shall be used to estimate the settlement of a pile group, using the equivalent footing location shown in Figure 4.12.3.2.1-1. 230 BoxGirders .... 265 OUTSTANDING LEGS OF ANGLES ....266 EXPANSION AND CONTRACTION ....266 FLEXURAL MEMBERS .... Anchors are usually required for support of both temporary and permanent nongravity cantilevered walls higher than about 5 meters (15 feet), depending on soil conditions. If there are eyebars among the parts connected, the diameter of the pin shall be not less than 3 [z + (yield point of steel) times the width of 400,000 the body of the eyebar in inches (10- 11) 10.25.4 Pin Plates When necessary for the required section or bearing area, the section at the pin holes shall be increased on each segment by plates so arranged as to reduce to a minimum the eccentricity of the segment. 425 Crack Control .... E HIGHWAY BRIDGES 749 750 HIGHWAY BRIDGES APP-E APP.E HIGHWAY BRIDGES 751 APP. 401 Geometric Requirements .... 387 Characteristics .... 10.33.1.2 The compression flanges of rolled beams supporting timber floors shall not be considered to be laterally supported by the flooring unless the floor and fastenings are specially designed to provide adequate support. 184 Pier Protection .... Scope .... 25 ELECTRIC RAILWAY LOADS .... Where scour is likely to occur, protection against damage from scour should be provided in the design of bridge piers and abutments. 541 FINISHING FORMED CONCRETE SURFACES ....541 General ....;........................... 3.27 .- -- -- DIVISION I- -- 3.27 DISTRIBUTION OF WHE~LLOADSON~ STEEL GRID FLOORS* 3.27.1 General 3.27.1.1 The grid floor shall be designed as continuous, but simple span moments may be used and reduced as provided in Article 3.24. Where relief bridges are needed to maintain the natural flow distribution and reduce backwater, caution must be exercised in proportioning the size and in locating such structures to avoid undue scour or changes in the course of the main river channel. 540 Steam or Radiant Heat Curing Method .... 214 Reinforcement for Hollow Rectangular Compression Members ...214 REINFORCEMENT OF COMPRESSION MEMBERS .... For footings in or above cohesive soil slopes, the stability number in the figures, N,, is defined as follows: For circular footings, B equals L. C10.48.5 Transversely Stiffened Girders C-128 HIGHWAY BRIDGES Language is also added to indicate that if the web slenderness Dlt, of a symmetric transversely stiffened girder exceeds the upper limit given by Equation (10-104), either the section must be modified to comply with the limit or longitudinal stiffeners must be provided. 5.3.5 Scour The probable depth of scour shall be determined by subsurface exploration and hydraulic studies. See also C10.49.3.2 (1997). FIGURE 5.8.4.1A Calculation of Vertical Stress for Horizontal Backslope Condition, Including Live Load and Dead Load Surcharges for Internal Stability Design not be used without full scale wall data (e.g., reinforcement loads and strains, and overall deflections) which supports the acceptability of larger vertical spacings. The shapes of rail members are illustrative only. 340 SoilDesign .... See %nterkorn and Fang (1975) for values of T for other ex- FIGURE 4.4.7.2.3C Reduction Factor to Account for Effects of Three-Dimensional Consolidation Settlement EPRI (1983) 4.4.7.2.3 DIVISION I-DESIGN cess pressure distributions. 598 Surface Finishes of Stone ....598 Rubble Masonry .... 5.5.6.5 DIVISION I-DESIGN a. 411 16.4.4.2.1.1 Standard Installations ....411 16.4.4.2.1.2 Nonstandard Installations .... 574 574 Position for Heating .... C10.58 FATIGUE C10.58.1 General Web Shear Buckling C-136 HIGHWAY BRIDGES tion. whichever 1s lower+. 10.15.2.2 In addition to the above requirements, the radius shall not be less than 1,000 feet when the flange thickness exceeds 3 inches or the flange width exceeds 30 inches. xliii .... Recommended test methods for soil chemical property determination include AASHTO T 289 for pH, AASHTO T 288 for resistivity, AASHTO T 291 for chlorides, and AASHTO T 290 for sulfates. The stiffener area requirement is based upon the load that the stiffener must support. Note that the uncertainty of determining long-term reinforcementstrength is taken into account through an additional factor of safety, which is typically about 1.2, depending on the amount of creep data available, through the creep extrapolation protocol provided in Appendix B of the FHWA-SA-96-071, "Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines." 5.8.7 Soil Reinforcenflacing Connection Strength Design 5.8.7.1 Connection Strength for Steel Soil Reinforcements Connections shall be designed to resist stresses resulting from active forces (To, as described in Article 5.8.4.2) as well as from differential movements between the reinforced backfill and the wall facing elements. As indicated in the new Equation (10-98), the tension-flange capacity is based on the yield stress F,. .655 . Sh: b = 1 unit width) s a f e t y f a c t o r (see A r t i c l e 5.8.6.2) = combined reductron f a c t o r t o account f o r longterm degradatron (see A r t r c l e 5.8.6.1.2). 383 SECTION 14-BEARINGS 385 SCOPE .... 665 Box Culverts .... 10.24.5 Spacing of Fasteners 10.24.5.1 Pitch and Gage of Fasteners The pitch of fasteners is the distance along the line of principal stress, in inches, between centers of adjacent fasteners, measured along one or more fastener lines. In cases where seepage forces are present, they should. .I44 Figures CONTENTS lxxv -- Figure 5.8.3B Figure 5.8.4.1A Figure 5.8.4.1B Figure 5.8.4.1C Figure 5.8.5.1A Figure 5.8.5.2A Figure 5.8.6A Figure 5.8.6B Figure 5.8.7.2A Figure 5.8.9.1A Figure 5.8.9.2A Figure 5.8.10A Figure 5.8.12.1A Figure 5.8.12.1B Figure 5.8.12.1C Figure 5.8.12.1D Figure 5.8.12.4A Figure 5.9.2A Figure 5.9.3B Figure 5.14.6-1 Figure 5.14.6-2 Figure 5.14.6-3 Figure 5.14.7-1 - Calculation of Vertical Stress for Bearing Capacity Calculations (for Sloping Backslope Condition) ....I45 Calculation of Vertical Stress for Horizontal Backslope Condition, Including Live Load and Dead Load Surcharges for Internal Stability Design ....I47 Calculation of Vertical Stress for Sloping Backslope Condition for Internal Stability Design .... Timedependent settlement shall be determined using only the permanent loads. If traffic lane widths exceed 12 feet the roadway width may be reduced 2 feet 0 inches from that calculated from Figure 2.5. 2.6 HIGHWAY CLEARANCES FOR DEPRESSED ROADWAYS 2.6.1 Roadway Width The clear width between curbs shall be not less than that specified for tunnels. wp 4.25 +28 or 3, whichever is 5.50 greater. .C-66 DIVISION I1 CONSTRUCTION SECTION 8-CONCRETE STRUCTURES Table 8.2 Table 8.3 Untitled . The uplift displacement (p,) at the butt of drilled shafts fully socketed into rock may be determined using the following which is modified to include elastic shortening of the shaft: Tolerable axial displacement criteria for drilled shaft foundations shall be developed by the structural designer consistent with the function and type of structure, fixity of bearings, anticipated service life, and consequences of unacceptable displacements on the structure performance. Bearing elements for anchors shall be designed to maintain shear stresses in the vertical wall elements and facing within allowable values. 615 Coal-tar Roofing Cement ....615 IDENTIFICATION AND INSPECTION ....615 Branding and Job Site Inspection .... It shall not apply to pins used in members having rotation caused by expansion or deflection. 70% strength retained after 500 hrs in weatherometer Min. 104.1 Figure C4.13.3.3.4-1 Elastic Settlement Influence Factor as a Function of Embedment Ratio and Modulus Ratio after Donald, Sloan and Chiu, 1980, as presented by Reese and O'Neill(1988) ... PIS the s o i l / For d~scontinuouss o i l r e i n f o r c e m e n t r (e.9.. 10.18.5.3 design shall be designed for not less than the average of the required strength at the point of connection and the strength of the member at the same point, but, in any event, not less than 75% of the strength of the member. Refer to Gifford, et al., (1987) for general guidance regarding the estimation of elastic settlement of footings on sand. SECTION 5-DESIGN REQUIREMENTS FOR BRIDGES IN SEISMIC PERFORMANCE CATEGORY A 5.1 5.2 5.3 5.4 5.5 GENERAL .... .34 JNDATIONS Problem Conditions Requiring Special Consideration .... A smooth transition by means of a continuation of the bridge barrier, guardrail anchored to the bridge end, or other effective means shall be provided to protect the traffic from direct collision with the bridge rail ends. Alternately, the vertical wall elements and facing are continuous and, therefore, also form the structural facing. 537 -Division Il CONTENTS Filled Joints .... Dl115 90,000 psi, Y.P. Min. FIGURE 5.8.6B Parameters for GeosyntheticReinforcementStrength Calculations 5.JL6.1 5.8.6.1 DIVISION I-DESIGN gressive soil criteria. 83 4.6.5.2.1 Soil Layering and Variable Soil Strength with Depth . 107 4.13.3.3 Resistance at Strength Limit States .... In regions where freezing of the ground occurs during the winter months, footings shall be founded below the maximum depth of frost penetration in order to prevent damage from frost heave. 4.5.21.3 Limitations on Treated Timber Pile Use .... 535 Bonding .... .86 4.6.5.3.3 Method of Construction ....86 4.6.5.4 Factors of Safety . 10.16.123 The top chord shall be considered as a column with elastic lateral supports at the panel points. Geosynthetic facing elements shall not, in general, be left exposed to sunlight (specifically ultraviolet radiation) for permanent walls. Part B SERVICE LOAD DESIGN METHOD ALLOWABLE STRESS DESIGN 5.5 RIGID GRAVITY AND SEMI-GRAVITY WALL DESIGN 5.5.1 Design Terminology Earth pressure loading on rigid gravity and semi-gravity walls is a function of the type and condition of soil backfill, the slope of the ground surface behind the wall, the friction between the wall and soil, and the ability of the wall to translate or rotate about their base. Very approximate estimates of settlements adjacent to braced or anchored flexible walls can be made using Figure 5.7.2B. 493 Site Work .... SINGLE MODE SPECTRAL ANALYSIS METHODPROCEDURE 2 .... 5.7.5 Structure Dimensions and External Stability The design of anchored walls includes determination of the following: Size, spacing, and depth of embedment of vertical wall elements and facing; v p e , capacity, spacing, depth, inclination and corrosion protection of anchors; and Structural capacity and stability of the wall, wall foundation, and surrounding soil mass for all intermediate and final stages of construction. Singly symmetric and unsymmehic compression members, such as angles or tees, and doubly symmehic compression members, such as cruciform or built-up members with very thin walls, may also require consideration of flexural-torsional and torsional buckline. For footings supported on piles or drilled shafts, the spacing between piles and drilled shafts shall be designed to ensure nearly equal loads on deep foundation elements as may be practical. These requirements must be satisfied when the girder is in the final condition. Pin nuts shall be malleable castings or steel. If curbs or sidewalks are not used, the wheel load shall be 1 foot from the face of the rail. 427 Concrete Cover for Reinforcement ....427 Geometric Properties .... ; .... 2.7.1.3.2 Rails whose traffic face is more than 1 inch behind a vertical plane through the face of the traffic rail closest to traffic or centered less than 15 inches above the reference surface shall not be considered to be traffc rails for the purpose of distributing P or CP, but may be considered in determining the maximum clear vertical opening, provided they are designed for a transverse loading equal to that applied to an adjacent traffic rail or Pl2, whichever is less. The lateral distribution shall be determined as follows. 601 Arches .... Curved Sheet PTFE . 380 General .... 10.34.2.1.5 In the case of a composite girder the ratio of the top compression flange plate width to thickness shall not exceed the value determined by the formula 10.34.2.2.6 Flange plates shall be of equal thickness, or shall decrease in thickness from the flange angles outward. A simplified procedure for testing drilled shafts permitting determination of the relative contribution of side resistance and tip resistance to overall shaft capacity is also available (Osterberg, 1984). C7.3.6 Structure Backfill Material C11.4.7 Straightening Material C7.3.6.3 Mechanically Stabilized Earth Walls These revisions allow the definition of nonaggressive soil to be moved to Division I, since the definition of nonaggressive soil is needed for design purposes, and is not intended for the development of construction specifications. MEASUREMENT AND PAYMENT ....589 SECTION 13.P AINTING GENERAL .... 268 xxix CONTENTS General ....268 Truss Members ....268 Secondary Stresses .... 165 Concentrated Dead Loads .... 424 16.6.3 Concrete Cover for Reinforcement . 508 Miscellaneous Elements ....508 FABRICATION .... 45 4.4.1 General ....45 45 4.4.1.1 Applicability .... 396 Scope .... .227 CONCRETE ....228 REINFORCEMENT .... 126 Seismic Pressure ....126 Structure Dimensions and External Stability ....126 Structure Design ....126 Base or Footing Slabs ....126 Wall Stems .... 305 Horizontalshear . .450 Elastic Seismic Response Coefficient for Single Mode Analysis . T or Rev T or Rev C See Notee 14 Base metal at intermittent fillet welds. 342 Service Load Design-safety factor, SF ....342 . 5.5.6.4 Reinforcement Except in gravity walls, not less than 81 mm2 ('/a square inch) of horizontal reinforcement per 0.3 meter (1 Friction Factor f = tan ti (dim) Friction Angle, 6 (degrees) 0.70 0.55 to 0.60 0.45 to 0.55 0.35 to 0.45 0.30 to 0.35 0.40 to 0.50 0.30 to 0.35 35 29 to31 24 to 29 19 to 24 17 to 19 22 to 26 17 to 19 0.40 0.30 0.25 0.20 22 17 14 11 0.40 to 0.50 0.30 to 0.40 0.30 0.25 22 to 26 17 to22 17 14 0.70 0.65 0.55 0.50 0.30 35 33 29 26 17 foot) of height shall be provided near exposed surfaces not otherwise reinforced to resist the formation of temperature and shrinkage cracks. (f) Geomorphic changes in channel flow. Crawford, Jr. NEW HAMPSHIRE, Mark Richardson NEW JERSEY, Harry A. Figures 5.8.2A, 5.8.2B, and 5.8.2C illustrate external stability equations for MSE walls with horizontal backslope, inclined backslope, and a broken backslope, respectively. 613 SECTION 17PRESERVATIVETREATMENT OF WOOD 17.1 17.2 17.2.1 17.2.2 17.2.3 17.3 17.3.1 17.3.2 17.3.3 17.4 GENERAL .... 341 Wall Area .... , a = proportional limit stress perpendicular to grain ?The equations are developed for deck panel spans equal to or greater than the width of the tire (as specified in Article 3.30), but not greater than 200 inches. 86 4.6.5.5.1.1 4.6.5.5.1.2 Cohesionless Soil . Surfacepreparation ....592 Blast Cleaning .... 16.4.2.3 Concrete Cover for Reiriforcement . 681 Weather Restrictions . 8 Clearance Diagrams for UnderPasses . 650 Cast-in-Place Concrete Slope Paving . An editorial revision is indicated to clarify that the moment of inertia of a transverse stiffener(s) is to be taken about the plane that is explicitly defined in Article 10.34.4.8. The mid-plane of the web is to only be used when there is a pair of stiffeners. Sheikh-Ibrahim and Karl H. #Ptn oc KEY F I4 d 4 .. E = maximum induced stress in the bottom flange, MPa (Article 10.20.2.1) = maximum compressive stress, MPa (Article 10.41.4.6) = allowable axial unit stress, MPa (Table 10.32.1A and Articles 10.36, 10.37.1.2, and 10.55.1) = allowable bending unit stress. The existing language regarding moment redistribution is moved into this paragraph so it applies to both noncomposite and composite sections. All fastenings shall be galvanized or made of corrosion-resistant material. 2.7.1.2.5 The traffic faces of all traffic rails must be within 1 inch of a vertical plane through the traffic face of the rail closest to traffic. 'Transversely Loaded" signifies direction of applied stress is perpendicular to the longitudinal axis of the weld. Subsequently, AISC removed the lower limit of 0.4 in the fist edition of the AISC LRFD Specijications (Reference 10). 567 High-Strength Fasteners .... The applied load to the reinforcements, T-, shall be calculated on a load per unit of wall width basis. 540 540 Forms-In-Place Method .... 601 Dowels and Cramps .... 554 UnbondedSystems ....554 Special Anchorage Device Acceptance Test . .93 General .... 204 Compression Member Strengths .... Metal materials with less than 10-percent tested elongation shall not be used. > 'Ransition radius 2: 2 in. Tests .... Similar language was formerly located at the end of Article 10.48.4.1. The yield stress F, in the denominator of Equation (10-104) is not replaced with the factored bending stress in the compression flange fb because the current slenderness limit (based on F,) defines a somewhat arbitrary upper bound below which fatigue due to excessive lateral web deflections is not considered to be a concern. 108 4.13.3.3.8~ Group in Strong Soil Overlying Weaker Compressible Soil ...108 4.13.3.3.9 DynamicISeismic Design .... Fatigue Stress Limits . 566 Camber Diagram .... Fullerton NEBRASKA, Lyman D. 259 DEPTH RATIOS .... These Standard Specifications are applicable to new structure designs prior to 2007 and for the maintenance and rehabilitation of existing structures. (b) Detail thickness r 1.0 in. = 0.33Fy Bearing on milled stiffeners and other 0.80Fy steel parts in contact (rivets and bolts excluded) g Stress in extreme fiber of pins 0.80Fy F, = 0.40Fy Shear in pins Bearing on pins not subject to rotationh 0.80Fy Bearing o n pins subject to rotation (such as used in rocken and hinges) 0.40Fy Bearing on connected material at Low Carbon Steel Bolts (ASTM A 307). 321 Shear .... The performance factor for axial compressive capacity, axial uplift capacity, and lateral capacity obtained from load tests shall be as provided in Table 4.10.6-3. The current specification language does not recognize the state of stress in the concrete deck in 199912000 COMMENTARY determining the requirement for longitudinal deck reinforcement; the tensile strength of the concrete is ignored. 72 Dynamic/Seismic Design . Non-interconnected* nail laminated panel floor: 15 inches, but not to exceed panel width. The base of the vertical wall elements should be located below any soft soils which are prone to settlement, as settlement of the vertical wall elements can cause destressing of the anchors. .221 Deformed Wire Fabric ....221 Smooth Wire Fabric ....222 MECHANICAL ANCHORAGE .... For conditions which are outside these defined limits (i.e., applications in which the consequences of poor performance or failure are severe, aggressive soil conditions, or polymers which are beyond the specific limits set), or if it is desired to use an overall reduction factor which is less than the default reduction factor recommended herein, then product specific durability studies shall be carried out prior to use. Interconnected* glued laminated panel floor, with adequate shear transfer between panels**, not less than 6 inches thick: 15 inches plus twice thickness of floor, but not to exceed panel width. Both the non-composite and composite dead-load shears are critical in checking the stability of the web during construction. 2 A FOR GENERAL NOTES AND LEGEND FIGURE 5.6.2A Simplified Earth Pressure Distributionsfor Permanent Flexible Cantilevered Walls With Discrete Vertical Wall Elements 5.5.6.5 Expansion and Contraction Joints 5.6 NONGRAVITY CANTILEVERED WALL DESIGN Contraction joints shall be provided at intervals not exceeding 9 meters (30 feet) and expansion joints at intervals not exceeding 27 meters (90 feet) for gravity or reinforced concrete walls. 197 Concrete .... -23 CENTRIFUGAL FORCES .... 5.5.6.3 Counterfortsand Buttresses Counterforts shall be designed as rectangular beams. 493 Pointing .... Fb= allowable flexural stress for the flange under consideration at the point of splice R = reduction factor for hybrid girders specified in Article 10.40.2.1. R shall be taken equal to 1.0 when fcfis less than or equal to the allowable flexural stress for the web steel. It should be noted that in most cases, the above procedure will only need to be implemented for composite noncompact sections in positive Jlexure with longitudinally stiffened webs that have relatively large values of D, For composite sections in positive bending without longitudinal web stiffeners, either the section will typically qualijj as compact, or should the section be noncompact, the Rb factor calculated from Equation (10-103b) will typically exceed 1.0 (and must therefore be set equal to 1.0) unless D, is unusually large. The net section through the hole shall provide 140% of the net section required for the actual stress transmitted through the pedestal or shoe. 10.16.11.2 Re-entrant cuts, except curves made for appearance, shall be avoided as far as practicable. 333 Bolts Subjected to Prying Action by Connected Parts ....333 Rigid Connections ....333 . NOTES: 1. 486 COFFERDAMS AND SHORING .... 687 Bedding Material and Structural Backfill .... .404 . 536 Rubber Waterstops ....; ....536 Polyvinylchloride Waterstops ....536 Copper Waterstops ....537 Testing of Waterstop Material ....537 Installation ....537 Open Joints .... The definition of the transverse stiffener spacing is modified to remove the word actual in front of the words distance between stiflener. 602 SECTION 15-CONCRETE BLOCK AND BRICK MASONRY DESCRLPTION .... 689 LIST OF FIGURES DIVISION I DESIGN SECTION %GENERAL FEATURES OF DESIGN Figure 2.3.1 Figure 2.4A Figure 2.5 Figure 2.7.4A Figure 2.7.4B Clearance Diagram for Bridges .... .C-71 DIVISION n CONSTRUCTION SECTION 16-TIMBER STRUCTURES Figure 16.3 Nail Placement Pattern ....613 SECTION 2bMETAL CULVERTS Figure 26.5 Figure 26.5.2 Figure 26.5.3 Figure 26.5.4 Typical Cross-Section Showing Materials Around the Pipe ....663 A-D: Foundation Improvement Methods When Required . tensible reinforcements are not mixed with extensible reinforcements within the same wall. They shall be held securely in position, usually by being inset into the metal of the pedestals or sole plates. For information on dynamic deflection of various baniers, see AASHTO Roadside Design Guide. The critical buckling force of the column, so determined, shall exceed the maximum force from dead load, live load, and impact in any panel of the top chord by not less than 50%.* *For a discussion of columns with elastic lateral supports, refer to Timoshenko& Gere, "Theory of Elastic Stability,"McGtaw-HillBook CO., Fit Edition, p. 326 COMPOSITE BOX GIRDERS ....326 .MaximumStrength .... 330 Maximum Capacity . 10.32.5.2 Malleable Castings Malleable castings shall conform to specifications for Malleable Iron Castings, ASTM A 47 Grade 35018. .423 . Since there is usually no convenient anchor on girder bridges, it is necessary prior to hardening of the deck concrete to restrain the relative longitudinal movement of the girders so that cross bracing is effective in restraining lateral displacement and twist. Equation 5.8.5.2-1, but replacing T, with To,can be used to deter- Facing elements shall be designed to resist the horizontal forces calculated according to Articles 5.8.4.2 and 5.8.9.3. In addition to these horizontal forces, the facing elements shall also be designed to resist potential compaction stresses occurring near the wall face during erection of the wall. 342 Handling and Installation Strength .... Non-interconnected glued laminated panel floor: 15 inches plus thickness of floor, but not to exceed panel width. .90 . 10.18.4.2 As a minimum, in the case of the strength design method, high-strength bolted connections for splices in tension members shall be proportioned to prevent slip at an overload design force, Po,equal to the maximum tensile stress in the member due to D + p, (L + I) times the gross area of the member, where p, is defined in Article 3.22. 422 16.4.6.6.6 Radial Stirrups ....422 16.4.6.6.1 Radial Tension Stinups .... 232 Concrete .... .453 SECTION 7-DESIGN REQUIREMENTS FOR BRIDGES IN SEISMIC PERFORMANCE CATEGORIES C AND D Table C7.2.2A Recommended Increased Values of Materials Properties . Further, footing excavations shall be made such that hydraulic gradients and material removal do not adversely affect adjacent structures. 251 MATERIALS .... 634 PAYMENT .... 4.11.3.2 Loads Immediate settlement shall be determined using the service load combinations given in Table 3.22.1A. 78 4.6 DRILLED SHAFTS . 292 Cast Steel, Ductile Iron Castings, Malleable Castings, and Cast Iron . or shafts extending into rock, a minimum of 3 meters (10 feet) of rock core, or a length of rock core equal to at least three times the shaft diameter, which ever is greater, shall be obtained to insure that the exploration has not been terminated on a boulder and to determine the physical characteristics of the rock within the zone of foundation influence for design. .674 Haunch Material ....674 . Minimum Radius of Curvature . For homogeneous girders, R shall always be taken equal to 1.o. Rf = the absolute value of the ratio of Fcfto fcffor the controlling flange fnCf= flexural stress at the mid-thickness of the noncontrolling flange at the point of splice concurrent with fcf(positive for tension; negative for compression) 10.18.2.3.9 As a minimum, in the case of the service load design method, web splice plates and their connections shall be proportioned to develop the most critical combination of FwDtw,M,, M, and H,. 532 Vertical Members .... 117 NOTATIONS ....117 PART B-SERVICE LOAD DESIGN METHOD ALLOWABLE STRESS DESIGN RIGID GRAVITY AND SEMI-GRAVITYWALL DESIGN ....121 Design Terminology ....121 121 Earth Pressure and Surcharge Loadings .... 51 4.4.7.1.1.4 Ground Surface Slope .... 32 Outside Roadway Stringers and Beams Steel-Timber-ConcreteT-Beams ....32 Concrete Box Girders .... E HIGHWAY BRIDGES 759 760 HIGHWAY BRIDGES APP.E 762 HIGHWAY BRIDGES APP. ....-535 Bonding and Doweling to Existing Structures .... Minimum Diameter of Tapered Piles ....75 DrivingPoints . .373 . Connections for main members in the case of load factor 10.19.1.4 In the case of connections which transfer total member shear at the end of the member, the gross section shall be taken as the gross section of the connected elements. 686 PAYMENT .... 567 Dimensions ....567 Galvanized High-Strength Fasteners .. 287 End Panel of Skewed Bridges .... An editorial change is also indicated immediately above Equation (10-129d). The indicated revisions to this LFD article parallel the revisions to ASD Article 10.34.4.7 (see the earlier discussion on the revisions to Article 10.34.4.7). 2.7.1.2 Geometry 2.7 RAILINGS Railings shall be provided along the edges of structures for protection of traffic and pedestrians. *Provisions in this article shall not apply to orthotropic bridge superstructures. Bracing . 10.9.2 If a double angle or tee section tension member is connected with the angles or flanges back to back on opposite sides of a gusset plate, the full net area of the shapes shall be considered effective. 316 DESIGNTHEORY .... 401 LoadLocation .... For walls constructed along rivers and streams, embedment depths shall be established at a minimum of 0.6 meters (2 feet) below potential scour depth as determined in accordance with Article 5.3.5. 5.8.2 External Stability Stability computations shall be made by assuming the reinforced soil mass and facing to be a rigid

body. .64 Summary of Poisson's Ratio for Intact Rock, Modified after Kulhawy (1978) .... 355 355 Plastic Moment Requirements .... 487 TEMPORARY BRIDGES .... 488 General . ... 646 Precast Portland Cement Concrete Blocks andshapes .... 646 Reinforcing Steel .... For preliminary design, the following values of K may be used: 3.24.2.2 In designing sidewalks, slabs and supporting members, a wheel load located on the sidewalk shall be 1 foot from the face of the rail. (4) Pressure distributions below the exposed portion of the wall are based on an effective element width of 3b, which is valid for 2 5b. 2.7.1.1.2 Materials for traffic railings shall be concrete, metal, timber, or a combination thereof. 122. 645 Grout .... 646 Sacked Concrete Riprap .... 646 Pneumatically Applied Mortar .... 11.5.7 11.6 ERECTION .... 1979.) 1. Thermal and shrinkage effects can also cause tensile stresses in the deck in regions where such stresses might not otherwise be anticipated. The AASHTO ASD lateral-torsional buckling check for constructibility in this article implicitly assumes that a load factor of approximately1.82 (110.55) is applied to the unfactored dead loads. 550 Identification .... 550 HANDLING, STORING, AND SURFACE CONDITION OF REINFORCEMENT .... 550 PLACING AND FASTENING .... 550 . T or Rev D 15.17 T or Rev D 15.17 7,9,15,17 7,9,15 16 B C D E 16 C D E 16 D E Base metal at details connected with transversely loaded welds, with the welds perpendicular to the direction of stress: Base metal adjacent to details attached by fillet welds with length, L, in the direction of stress greater than 12 times the plate thickness or greater than 4 in.: (a) Detail thickness < 1.0 in. 510 Grouting .... 558 Metal Ducts .... 3.24.8.3 For continuous spans, the moment may be reduced by 20% unless a greater reduction results from a more exact analysis. The quality of in-service performance is an important consideration in the design of permanent retaining walls. 401 . 401 Contact Stress. 660 ASSEMBLY .... 5.2.2.2 Settlement MSE walls may be constructed for use under the following special conditions: When two intersecting walls form an enclosed angle of 70° or less, the affected portion of the wall is designed as an internally tied bin structure with at-rest earth pressure coefficients. Regardless of cap contact with the ground, the individual capacity of each shaft shall be reduced by a factor q for an isolated shaft, where q = 0.67 for a center-to-center (CTC) spacing of three diameters and q = 1.0 for a center-to-center spacing of eight diameters. .267 .. 533 Consolidation .... Splices may be developed by lapping, welding, and special approved connectors. Final determination of the anchor capacity and required bond length shall be the responsibility of the anchored wall specialty contractor. In general, the pseudo-static approach developed by Mononobe-Okabe may be used to estimate the equivalent static forces provided the maximum lateral earth pressure be computed using a seismic coefficient kh =1.5A. Internalinertial force due to the weight of the backfill within the active zone. 505 Payment .... 520 . 10.18 SPLICES 10.18.1 General 10.18.1.1 Design Strength Splices may be made by rivets, by high-strength bolts or by the use of welding. .... 647 D~yPlacement. OF THE ARMY, Paul Tan U.S. COAST GUARD, Jacob Patnaik U.S. DEPARTMENT OF AGRICULTURE/FOREST SERVICE. 147 Determination of Reinforcement Length Required for Internal Stability .... 147 Location of Zone of Maximum Stress .... 147 Soil Reinforcement Pullout Design .... 148 . 4.6.5.3.3 Factors Affecting Axial Capacity in Rock 4.6.5.3.3.1 Rock Stratification Rock stratification shall be considered in the design of rock sockets as follows: UNCONFINED COMPRESSIVE STRENGTH OF ROCK OR CONCRETE, WHICHEVER IS WAKER,qc(psi) FIGURE 4.6.5.3.1A Procedure for Estimating Average Unit Shear for Smooth Wall Rock-Socketed Shafts Horvath, et al. For composite sections in positive moment regions, using one of the same equations shall be used, using the web of the girder the flange (web of the girder shall be used with the bottom flange) to determine which value of A to use, it is too conservative because of the support offered to the web by the top flange and concrete deck acting together. 530 Steam and Radiant Heat-Cured Concrete .... 530 PROTECTION OF CONCRETE FROM ENVIRONMENTAL CONDITIONS .... Predrilled Holes in Embankments .... Therefore, the appropriate language is added to permit their use. 30 BUOYANCY .... xix xx CONTENTS Nongravity Cantilevered Walls .... 571 Facing of Bearing Surfaces . In 1997, Section 15, "TFE Bearing Surface," Division I, was replaced by Section 14, "Bearings." 4. The ultimate bearing capacity of piles may be estimated using analytic methods or in situ test methods. Capacity may be verified with load test results. 73 . LINKSANDHANGERS .... 284 Net Section .... 284 Location of Pins . 108 4.13.3.3.7 Lateral Load .... 387 Horizontal Force .... A complete specification was available in 1926 and it was revised in 1928. At joints where the flanges of one member are rigidly framed into one flange of another member, the thickness of the web, t, supporting the latter flange and the thickness of the latter flange, &, shall be checked by the formulas below. 67 Transfer of Force at Base of Column .... 138 Structure Dimensions .... 138 Bearing Capacity and Foundation Stability .... 143 Calculation of Loads for Internal Stability Design .... 144 Calculation of Maximum Reinforcement Loads .... When the areas of the inner and outer plates differ by more than lo%, the design force in each splice plate and its connection shall be determined by multiplying the flange design force by the ratio of the area of the splice plate under consideration to the total area of the inner and outer splice plates. 537 FINISHING PLASTIC CONCRETE . GENERAL . 4.12.3.3.2 When piles are subjected to uplift, they should be investigated for both resistance to pullout and their structural ability to resist tension. Dl f40 70,000 psi, Y2 Min. For geosynthetic reinforcement rupture, the reinforcement must be designed to resist the static and dynamic components of the load as follows: For the static component; 5.8.9.2 If the seismic performance category is "C" or higher (see Section 3, Division I-A), facing connections in segmental block faced walls shall not be fully dependent on frictional resistance between the backfill reinforcement and facing blocks. 136 General .... Precast concrete placed on sand using estimated from SPT data using +f estimated from CPT data b. Where the tip of a shaft would bear on thin rigid rock strata underlain by a weaker unit, the shaft shall be extended into or through the weaker unit (depending on load capacity or deformation requirements) to eliminate the potential for failure due to flexural tension or punching failure of the thin rigid stratum. 7.3.1.2 Materials for pedestrian railing may be concrete, metal, timber, or a combination thereof. 412 xli xlii CONTENTS Loads .... 467 Pier Design Forces .... If the footing width is small relative to the thickness of the compressible soil, the effect of three-dimensional (3-D) loading may be considered using the following: I Vartical r t f c i v s t r e s s, v(lop scala) FIGURE 4.4.7.2.3B Typical Consolidation Compression Curve for Overconsolidated SoilVoid Strain Versus Vertical Effective Stress Overconsolidation ratio, 4 /uO1 Refer to Figure 4.4.7.2.3C for values of k. 4.4.5.1 Minimum Embedment and Bench Width Footings not otherwise founded on sound, non-degradable rock surfaces shall be embedded a sufficient FIGURE 4.4.3A Design Terminology for Spread Footing Foundations 4.4.5.1 DIVISION I-DESIGN depth to provide adequate heaving, scour and frost protection, or 2 feet to the bottom of footing, whichever is greatest. Pangalinan NEW BRUNSWICK, David Cogswell NORTHAMPTON, R. 215 Ties . DESIGN REQUIREMENTS FOR SINGLE SPAN BRIDGES ....451 REQUIREMENTS FOR TEMPORARY BRIDGES AND STAGED CONSTRUCTION ....452 . whichever is lowest, ' f a n P 1s for continuous soil reinforcements (6.9). Temporary MSE walls are typically designed for a service life of 36 months or less. In tension members the pitch shall not exceed twice that specified for compression members and the gage shall not exceed that specified for tension members. 3.26.1.2 For composite T-beams of wood and concrete, as described in Article 20.19.2, Division I1, the effective flange width shall not exceed that given in Article 10.38.3. Shear connectors shall be capable of resisting both vertical and horizontal movement. Sun -nts about the point of action of F to determine the embedment (D f for which the net passive pressure is sufficient to provide equilibrium. The language regarding violation of the web thickness requirement in Article 10.48.2.1(b) is eliminated in this article because this condition is now handled sufficiently and more clearly by the direct incorporation of the Rbfactor in new Equation (10-99) in Article 10.48.2 (see above). If another analytic method is used, application of the performance factors in Table 4.10.6-3 may not be appropriate. These 6'14 limits are not applicable to rigid frame structures. 402 LOAD PLATES AND ANCHORAGE FOR BEARINGS .... 402 Plates for Load Distribution .... MSE walls can tolerate larger total and differential vertical deflections than rigid walls. 612 Trusses .... 275 Compression Members .... 108 4.13.4.1 Buckling of Drilled Shafts .... Short slotted holes may be used without regard for the direction of applied load in any or all plies of connections which satisfy the requirements of Article 10.32.3.2.1 or Article 10.57.3.1, as applicable. 89 Tolerable Lateral Movements .... 86 Cohesivesoil . 427 Reinforcement .... 308 10.39.4.3 Compression Flanges Stiffened Longitudinally .... 308 10.39.4.1 Compression Flanges Stiffened Longitudinally ... 311 10.39.4.5 Compression Flange Stiffeners, General .... 312 10.39.5 Design of Flanges to Web Welds .... 341 Seam Strength ..... 165 Reinforcement for Temperature .... 16.5 REINFORCED CONCRETE ARCH, CAST-IN-PLACE .... .281 . 626 Requirements for All Geometric Requirements .... 626 . long-slotted holes parallel to be applied bearing force Bearing. 40 Design .... Jones, Sidney Poleynard, Jack F r e i d e ~ c h Henry, W. 515 Reinforcing Steel .... 7 Equations (10-93) and (10-95) are modified to use the full compression-flange width b in place of the projecting compression-flange width b' in computing the flange slenderness ratio. Footings at stream crossings shall be founded at depth below the maximum anticipated depth of scour as specified in Article 4.11.1.3. Footings not exposed to the action of stream current shall be founded on a firm foundation and below frost level. 608 FABRICATION AND CONSTRUCTION .... 609 Workmanship .... The web thickness of rolled beams or channels shall not be less than 0.23 inches. 403 LOADS .... In metal 3/8 inch thick and over, one-half of the depth of the countersink shall be omitted in calculating the bearing area. For Box-Section Beams: 3.24.2 Edge Distance of Wheel Loads where 3.24.2.1 In designing slabs, the center line of the wheel load shall be 1 foot from the face of the curb. .562 GROUTING .... 540 560 Liquid Membranes .... 2.C.Gravity walls derive their capacity to resist lateral loads through a combination of dead weight and lateral resistance. 597 RubbleMasonry . If a single slab covers the supporting stratum beneath the entire area of the superstructure, the foundation is known as a combined footing. (Article 4.6.5.1.3) = shaft diameter, m (Article 4.6.4.3) = diameter of enlarged base, m (Article 4.6.4.3) = least width of shaft group, m (Article 4.6.5.4.3) = diameter of rock socket, m (Article 4.6.5.3) = tip diameter, m (Article 4.6.5.1.3) = uniaxial compressive strength of rock mass, MPa (Article 4.6.5.3) = uniaxial compressive strength of intact rock, MPa = shaft length, m (Article 4.6.3) = length of rock socket, m (Article 4.6.5.3) = elastic modulus of shaft concrete or reinforced shaft, MPa = elastic modulus of rock mass, MPa = elastic modulus of intact rock, MPa = factor of safety, nondim. Longitudinal web stiffeners are subject to the same flexural This revision changes the heading of this LFD article from 'SYMMETRICAL BEAMS AND GIRDERS' to 'FLEXURALMEMBERS' . 5.8.5.2 Soil Reinforcement Pullout Design The reinforcement pullout resistance shall be checked at each level against pullout failure for internal stability. Rock -Semi-empirical procedure (Carter and Kulhawy) 2. A nongravity cantilevered wall includes an exposed design height (H) over which soil is retained by the vertical and facing elements, and a vertical element embedment depth (D) which provides lateral support to the vertical wall elements. MSE walls which contain a mixture of inextensible and extensible reinforcements are not recommended. INTRODUCTION The compilation of these specifications began in 1921 with the organization of the Committee on Bridges and Structures of the American Association of State Highway Officials. 451 . 485 Stay-in-Place Forms .... 486 Removal of Falsework and Forms . 105 4.12.3.3.11 DynamicSeismicDesign .... 434 Chemical and Mechanical Requirements . 233 233 LOSS OF PRESTRESS .... 461 Free-Standing Abutments .... 635 636 Compression Seal Joints .... .587 . 536 Contraction Joint General .... 536 Pourable Joint Sealants .... Hence, the limit of 1% weight loss after 150 cycles is provided in this revision. 551 Repair of Damaged Epoxy Coating .... 551 SPLICING OF BARS .... 4.4.6 Anchorage Footings founded on inclined, smooth rock surfaces and which are not restrained by an overburden of resistant material shall be effectively anchored by means of rock anchors, rock bolts, dowels, keys, benching or other suitable means. 400 Limits on Load and Geometry . That area in excess of 15%shall be deducted from the gross area. If site specific data for tan p is not available, use 0.67tan for the coefficient of sliding for continuous or near continuous reinforcement layers. 257 Weld Metal .... 666 Bracing .... The global safety factor of 0.55 applied to F, for permanent structures accounts for uncertainties in structure geometry, fill properties, externally applied loads, the potential for local overstress due to load nonu~formities,and uncertainties in long-term reinforcement strength. 89 . (1995). The influence of the group on the bearing capacity of soils or rocks, and settlements of the structure shall be considered. 388 Typical Bearing Components .... 389 Untitled .... Shallow keying of large footing areas shall be avoided where blasting is required for rock removal. 633 MEASUREMENT .... (c) 2 in. 242 Diaphragms .... 243 Multiple Slab Anchorages .... 243 Application of Strut-and-Tie Models to the Design . 41 Interior Beams .... 41 Exterior Beams . 619 Interlocked Bronze and Filled PTFE Structures . 609 Storage of Material .... 85 100 90-95 1 4 16 1 9 2-0 2 3 Good Fresh to slightly weathered rock, slightly disturbed with joints spaced 3 to 10 feet apart 65 10 75-90 0.28 0.32 0.38 0.40 0.46 Fair Rock with several sets of moderately weathered joints spaced 1 to 3 feet apart 44 1 50-75 0.009 0.056 0.066 0.069 0.081 Poor Rock with numerous weathered joints spaced 1 to 20 inches apart with some gouge 23 0.1 25-50 0.015 0.016 0.019 0.020 0.024 Very poor Rock with numerous highly weathered joints spaced < 2 inches apart 3 0.01 for shafts socketed into rock may be determined using the following: (SR= "FPB,D (0.14/qult) (4.6.5.3.1-1) Refer to Figure 4.6.5.3.1A for values of q,SR For uplift loading Q,, of a rock socketed shaft shall be limited to 0.7QsR. The use of presumptive values shall be based on the results of subsurface exploration to identify rock condition. (d) Information on ice, debris, and channel stability. (b) 2 in. 3.25.1.3 One design method for interconnected glued laminated panel floors is as follows: For glued laminated panel decks using vertically laminated lumber with the panel placed in a transverse direction to the stringers and with panels interconnected using steel dowels, the determination of the deck thickness shall be based on the following equations for maximum unit primary moment and shear" 392 Attachment .... 10.24.4.2 The diameter of fasteners in angles carrying calculated stress shall not exceed one-fourth the width of the leg in which they are placed. Procedures for designing members with variable moments of inertia can be found in the following references: "Engineering Journal," American Institute of Steel Construction, January 1969, Volume 6. Concrete Anchor Systems .... 316 10.41.4.9 316 10.41.4.10 Closed Ribs .... flkallowable bearing force for the connection is equal to the sum of the allowable bearing f n m for the individual bolts in the connection. These revisions are voted on by the Association Member Departments prior to the publication of a new edition of this book, and if approved by at least two-thirds of the members, they are included in a new edition as standards of the Association. 28] For these calculations, the depth "Z" is referenced from the top of the wall at the wall face, excluding any copings and appurtenances. 325 Connector Sections .... H' 2 37". the following equations may be used to determine the weighted average unit weight: + W'r Under longitudinal loading of a footing supported on the upper layer of a two-layer cohesive soil system, the bearing capacity may be determined by the following: FIGURE 4.4.7.1.1.6A Definition Sketch for Influence of Ground Water Table on Bearing Capacity 56 HIGHWAY BRIDGES Refer to Figure 4.4.7.1.1.7Afor the definition of cf. FIGURE 5.8.3A Calculation of Vertical Stress for Bearing Capacity Calculations (for Horizontal Backslope Condition) 5.8.4 8 DIVISION I-DESIGN = 145 Resultant of vertical forces - Note: For r e l a t i v e l y thick facing elements (e.g., segmental concrete facing blocks), it is acceptable to evaluate the stresses at the level of ... Method: D-Static Load Tests . 5.7.6.2 Anchor Design Anchor design shall include an evaluation of the feasibility of using anchors, selection of an anchor system, estimates of anchor capacity, determination of unbonded length, and determination of corrosion protection requirements. 396 Compressive Deflection .... 4.4.5 Depth 4.4.3 Design Terminology Refer to Figure 4.4.3Afor terminology used in the design of spread footing foundations. 528 MANUFACTURE OF CONCRETE .... 528 Storage of Aggregates .... 528 Storage of Cement .... 528 Measurement of Materials .... 529 529 Batching and Mixing Concrete .... Seepage forces and gradients may be evaluated by flow net procedures or other appropriate methods. 3.24.9 Unsupported Transverse Edges The design assumptions of this article do not provide for the effect of loads near unsupported edges. The effect of the longitudinal stiffener is not considered in determining the shear capacity of a girder and it has not been C-122 HIGHWAY BRIDGES studied in enough detail to do so. 4.6.5.3.3.1 4.6.5.5 Determination of Axially Loaded Shafts The settlement of axially loaded shafts at working or allowable loads shall be estimated using elastic or load transfer analysis methods. In load factor design, 1.0 may be used as the beta factor in place of 1.67 for the design of deck slabs. 1. A 16-foot clearance should be provided in both rural and urban areas where such clearance is not unreasonably costly and where needed for defense requirements. 611 Bracing = 10 in. 400 Clearances and Mating Surface .... 471 Column Requirements .... 345 .... Bearings are frequently specified with a PTFE sliding surface that moves in the pile. It is indicated in the table whether the standard truck or the lane loading produces the maximum stress. S n = b = l u n i t width). Using the subpanel depth in this requirement may lead to confusion and unintentional design errors. 4.5.6.2 Tolerable Lateral Movements Tolerable lateral displacement criteria for drilled shaft foundations shall be developed by the structural designer consistent with the function and type of structure, fixity of bearings, anticipated service life, and consequences of unacceptable displacements on the structure performance. HIGHWAY BRIDGES 140 5.8.2 HORIZONTAL BACKSLOPE WITH TRAFFIC SURCHARGE 1 i~Ilbllil I I I I I I I I~ Anchored I r e bearing capacity end o e r s I I (global) c o b I I I I y. Average Acceleration Spectra for Different Site Conditions (after Seed, et al., (1976) . 4.12.3.2.36 Cohesionless Soil The settlement of pile groups in cohesionless soils can be estimated using results of in situ tests, and the equivalent footing location shown in Figure 4.12.3.2.1-1. The arrangement of plates, angles, or other splice elements shall be such as to make proper provision for the stresses, both axial and bending, in the component parts of the members spliced. .617 . 157 .... 399 Shear .... 423 Design .... The long-term strength of each backfill surface should be considered as restoring forces in the limit equilibrium slope stability analysis. .612 Wheel Guards and Railing . AND TRAFFIC SIGNALS .... 337 BRIDGE RAILING .... Nongravity cantilevered walls are generally limited to a maximum height of approximately 5 meters (15 feet), unless they are provided with additional support by means of anchors. 377 Volume Factor, Cv .... METHOD. 516 Mechanically Stabilized Earth Walls .... 516 EARTHWORK .... 353 Standard Terminology of Structural Plate Box Culvert Shapes .... The effect of ground water level on the ultimate bearing capacity shall be considered by using a weighted average soil unit weight in Equation 4.4.7.1.1.1-1. Dowelling loads shall be considered as a load when the bearing capacity and settlement of pile foundations are investigated. 423 16.5.1 Application .... Bearings for spans less than 50 feet need have no provision for deflection. 303 10.38.2 Shear Connectors . 635 MANUFACTURE AND FABRICATION .... 4.4.2 Notations .... As a result, when the number of stiffeners exceeds two, the moment of inertia of the stiffeners required to achieve the desired k value increases dramatically so as 199912000 COMMENTARY to become impractical. 5.7.3 Water Pressure and Drainage 5.7.2 Refer to Article 5.7.2 for general guidance regarding wall deflections. 581 11.5.6.4.7b Installation .... 3.1 General Requirements As a minimum, the subsurface exploration and testing programs shall define the following, where applicable: Soil strata -Depth, thickness, and variability HIGHWAY BRIDGES TABLE 4.2.3A Problem Conditions Requiring Special Consideration Problem VP~ Soil Description Comments Organic soil; highly plastic clay Sensitive clay Micaceous soil Low strength and high compressibility Potentially large strength loss upon large straining Potentially high compressibility (often saprolitic) Expansive clay/silt; expansive slag Potentially large expansion upon wetting Collapsible soil Pyritic shale Potentially large deformations upon wetting (Caliche; Loess) Potentially large expansion upon oxidation Low strength when loaded parallel to bedding Potentially large expansion upon wetting; degrades readily upon exposure to air/water Expands upon exposure to air/water Degrades readily upon exposure to air/water Potentially large deformations due to earthquake loading ... Identification and classification -Quality (i.e., soundness, hardness, jointing and presence of joint filling, resistance to weathering, if exposed, and solutioning) -Compressive strength (e.g., uniaxial compression, point load index) -Expansion potential Ground water elevation Ground surface elevation Local conditions requiring special consideration Exploration logs shall include soil and rock strata descriptions, penetration resistance for soils (e.g., SPT or q,), and sample recovery and RQD for rock strata. Andersen INDIANA, Mary Jo Hamman IOWA, Norman L. Internal design of MSE wall systems requires knowledge of short and longterm properties of the materials used as well as the soil mechanics which govern MSE wall behavior. e t the base of the w a l l o r Tmp e t the lowest reinforcement layer f o r continuous reinforcements. Restrained walls are fixed or partially restrained against translation and/or rotation. Sliding on clay is controlled by the strength of the clay shear strength is less than 0.5 times the normal stress, and is controlled by the normal stress when the clay shear strength is greater than 0.5 times the normal stress. 10.16.14.6 The diameter of the hole shall be taken as inch greater than the nominal diameter of the rivet or high-strength bolt, unless larger holes are al with ~ ~ 10.24. Where discrete vertical wall elements are used for support, the width of each vertical element shall be assumed to equal the width of the flange or diameter of the element for driven sections and the diameter of the concrete-filled hole for sections encased in concrete. 4.4.7.2.4 Secondary Settlement Secondary settlement of footings on cohesive soil may be estimated using the following: s, = C,,Hclog(t2/t,) "'"T2a(1) t, is the time when secondary settlement begins (typically at a time equivalent to 90-percent average degree of consolidation),and t2is an arbitrary time which could represent the service life of the structure. Hole Types . Therefore, to once again reduce this significant inherent conservatism in the ASD constructibility check and make it more equivalent to the LFD check, the current ASD width-to-thickness requirement for the case of dead load acting alone is divided by resulting in the revised Equation (10-20). 10.28 FORKED ENDS Forked ends will be permitted only where unavoidable. Refer to Gifford, et al., (1987) for general guidance regarding static loading conditions and Lam and Martin (1986) for guidance regarding dynamicIseismic loading conditions. 61 4.4.7.3 Dynamic Ground Stability .... 467 Column and Pier Connections to Cap Beams and Footings .... 467 Foundation Design Forces .... 467 Abutment and Retaining Wall Design Forces .... 468 DESIGN DISPLACEMENT FOR SEISMIC PERFORMANCE CATEGORIES C AND D .... Any cover plate that is not full length shall extend beyond the theoretical cutoff point far enough to develop the capacity of the plate or shall extend to a section where the stress in the remainder of the girder flange is equal to the allowable fatigue stress, whichever is greater. Potential for reinforcement rupture and pullout are evaluated at the zone of maximum stress. 43 Foundation Capacity .... 43 Bearing Capacity .... 43 Settlement .... 43 Overall Stability .... Sloping Ground . No plate shall have a thickness greater than that of the flange angles. The slip resistance of the connection shall be determined as specified in Article 10.32.3.2.1. 10.18.5 Welded Splices .... 10.18.5.1 Tension and compression members may be spliced by means of full penetration butt welds, preferably without the use of splice plates. Minimum Bend Diameters 217 DEVELOPMENT OF FLEXURAL REINFORCEMENT . 570 Edgeplaning .... (See Figure 5.8.5.1A) + 6 FIGURE 5.8.4.1A Calculation of Vertical Stresses for Bearing Capacity Calculations (for Sloping Backslope Condition) 130 HIGHWAY BRIDGES For seismic loading conditions, the value of F*, the pullout resistance factor, shall be reduced to 80% of the values used for static design. The theoretical end of the end-bolted cover plate is determined in the same manner as that of a welded cover plate, as is specified in Article 10.13.4. The bolts in the slip-critical connections of the cover plate ends to the flange, shall be of sufficient numbers to develop a total force of not less than the computed force in the cover plate at the theoretical end. 470 Monolithic Abutments .... 688 Foundation and Bedding .... 407 16.1.3 Loads .... 409 16.1.4 Design .... 409 16.1.5 Materials .... 409 16.1.6 Soil Design .... 409 16.1.7 Abrasive or Corrosive Conditions .... 409 16.1.8 End Structures .... 409 16.1.9 Construction and Installation .... 409 16.2 SERVICE LOAD DESIGN .... 409 16.3 LOAD FACTOR DESIGN .... 409 16.4 REINFORCED CONCRETE PIPE .... 409 16.4.1 Application .... Stay plates shall be connected by not less than three fasteners on each side, and in members having lacing bars the last fastener in the stay plates preferably shall also pass through the end of the adjacent bar. 69 Flexible Watertight Gaskets .... 669 Other Joint Sealant Materials .... 670 Bedding, Haunch. Railing and wheel loads shall not be applied simultaneously. The design values shall be multiplied by 0.875 for diameters greater than 1 inch. 5.2.1.2 Nongravity Cantilevered Walls Nongravity cantilevered walls derive lateral resistance through embedment of vertical wall elements and support retained soil with facing elements. All joints shall be filled with approved filling material to ensure the function of the joint, .. 15 c(%wnC*- Diavh. 10.24.2.2.3 Long slotted holes may be used in one or both parallel parts of an individual faying surface in high-strength bolted connections designed on the basis of Table 10.32.3B or Table 10.56A, as applicable, provided TABLE 10.24.2 Nominal Hole Dimension Hole Dimensions Bolt Standard Oversize Short Slot Long Slot (Dia.) (Dia.) (Dia.) (Width X Length) (Width X Length) % %6 13/16 3/4 %6 l%6 l%6 1 1/16 1% x 8 1 1 21y8 d + v16 d + %6 x 'l/g x1 l%6 x 1% 1x6 x 15/16 '%6 '3/16 (d X 19/16 x 1% l%6 x 23/16 11/16 x 2% lY16 '%6 + yl6) x (d + %) (d + Y16) X (2.5 X d) 10.24.1.9 the load is applied approximately normal (between 80 and 100") to the axis of the slot. 40 Deflections .... 620 Special Material Requirements for Bronze or 18.4.6 Copper Alloy Sliding Surfaces .... T or Rev -With unequal plate thickness and reinforcement removed (a) Transition radius 2 2 in. SPECIAL DESIGN PROVISIONS FOR BEARINGS ....390 Metal Rocker and Roller Bearings .... 433 Buckling .... The active earth pressure coefficients for retained backfill (i.e., fill behind the reinforced soil mass) for external stability calculations only is computed as shown in Figure 5.5.2A, with 8 = P. 539 Tined .... - - - (See A r t r c l e 5.8.6.2.2) alloweble long-term t e n s i l e s t r e n g t h of reinforcement (strength/unit rernforcement wrdth) long- term tensrle strength required t o p r e v e n t rupture (r t r e n g t h l u n r t r e i n f o r c e m e n t width) = TYlr = HIGHWAY BRIDGES ....-.--p-p--...-.-------- wrde width tensile strength (s t r e n g t h / u n i t reinforcement width) :reinforcement coverage r a t i o : b s h = 1 Use R, FS RF = f o r continuous geosynthetlc sheets (1.e.. C-124 HIGHWAY BRIDGES C10.39.4.2.6 Current specification requirements only consider the effect of shear lag in box-girder bottom flanges subject to tension. Connections between steel reinforcement and the wall facing units (e.g., welds, bolts, pins, etc.) shall be designed in accordance with Article 10.32. .685 MATERIALS .... As a general guide, the following may be considered: For walls with a single anchor level-A triangular distribution defined by Kay per unit length of wall height plus surcharge loads. 52 4.4.7.1.1.5 HIGHWAY BRIDGES FIGURE 4.4.7.1.1.1A Definition Sketch for Loading and Dimensions for Footings Subjected to Eccentric or Inclined Loads Modified after EPRI (1983) mar eL RESULTANT CONTACT PRESSURE (0 1 FOR eL S + CONTACT ME§- (~ I I F O R TL< e L < - L 2 FIGURE 4.4.7.1.1.1B Contact Pressure for Footing Loaded Eccentrically About One Axis 4.4.7.1.1.5 DIVISION I-DESIGN LONGITUDINAL ECCENTRICITY / LENGTH OF FOOTING = eL/L SOUD CURVES GIVE VALUES OF K. 4.2.2.3 Overall Stability 4.2 FOUNDATION TYPE AND CAPACITY 4.2.1 Selection of Foundation Type Selection of foundation type shall be based on an assessment of the magnitude and direction of loading, depth to suitable bearing materials, evidence of previous flooding, potential for liquefaction, undermining or scour, swelling potential, frost depth and ease and cost of construction. 33 Bending Moments in Floor Beams (Transverse) ....34 Precast Concrete Beams Used in ~ u l t i - ~Decks e b ....34 DISTRIBUTION OF LOADS AND DESIGN OF CONCRETE SLABS ....; ....35 SpanLengths .... A minimum factor of safety of 1.1 shall be used when designing walls for seismic loads. APPLICABLE DOCUMENTS 617 AASHTO Standards ....617 ASTMStandards . Where sidewalks are used for pedestrian traffic on urban expressways, they shall be separated from the bridge roadway by the use of a combination railing as shown in Figure 2.7.4B. Therefore, to avoid potential problems, the word actual is removed. .... For intermediate spacings, the value of q may be determined by linear interpolation. # ')) m 1 2 0 n r w ~ O ~ O E N TOF PI P C05 l Q * - # *)) CRESL MSSIVE SOIL RSISTY(EE IN F M X l OC SNM KEY. u w '0' in lieu of 'Lm). 517 Structure Backfill .... .302 10.37.2 Web Plates . on bolt with threads in shear planed Bearing, F,,, on connected material m standard. 654 INSTALLATION ....654 . Finish 568 Certification ....569 Check Samples ....569 Steel Forgings and Steel Shafting .... 486 Time of Removal . 4.13.3.3.8 Group Capacity Possible reduction in capacity from group effects shall be considered. .597 . For rocks defined by very poor quality, the value of Q, cannot be less than the value of QTfor an equivalent soil mass. 4.11.3.3 Movement Criteria Vertical and horizontal movement criteria for footings shall be developed consistent with the function and type of structure, anticipated service life, and consequences of unacceptable movements on structure performance. 434 Maximum Strain .... Tho full rorght of a l l amgmont.1 facmg block unru rrthrn Hk m i l l bo conarderod act o t tho bow of tho lowormoat sogmont.1 facing block. Tukey MARYLAND, Earle S. 515 Concrete ....515 Cast-in-Place ....515 Pneumatically Applied Mortar ....515 Precast Elements .... Bearings with Curved Sliding Surfaces ....392 Geometric Requirements ....392 Resistance to Lateral Load ....393 PotBearings ....393 General .... The stiffener spacing required will depend upon the spacing needed in order to prevent differential panel movement; however, a stiffener shall be placed at mid-span with additional stiffeners placed at intervals not to exceed 10 feet. 462 STRUCTURAL STEEL DESIGN REQUIREMENTS FOR SEISMIC PERFORMANCE CATEGORY B ....462 462 General ....;.................. 287 Fasteners (Rivets and Bolts) .... The method of construction may affect the drilled shaft capacity and shall be considered as part of the design process. 104 Pile Group Uplift Capacity ....104 LateralLoad .... No. 1, and October 1972, Volume 9, No. 4; and "Steel Structures," by Wdliam McGuire. 4.2.2 Foundation Capacity Foundations shall be designed to provide adequate structural capacity, adequate foundation bearing capacity with acceptable settlements, and acceptable overall stability of slopes adjacent to the foundations. 2.7.2.2.6 Refer to Figures 2.7.4A and 2.7.4B for more information concerning the application of loads. The length of these angles shall be as great as the flanges will permit. Frank, "Bolted Splice Connections with Undeveloped Fillers," Journal of the Structural Division, ASCE, Vol. 603 Grout .... 436 + DIVISION I-A SEISMIC DESIGN SECTION 1-INTRODUCTION 1.1 1.2 1.3 1.4 1.5 1.6 PURPOSE AND PHILOSOPHY ....439 BACKGROUND ....439 BASIC CONCEPTS ....440 PROJECT ORGANIZATION .... Water flowing downgrade in a gutter section should be intercepted and not permitted to run onto the bridge. 5.8.6.1.2 Geosynthetic Reinforcement The durability of geosynthetic reinforcements is influenced by environmental factors such as time, temperature, mechanical damage, stress levels, and chemical exposure (e.g., oxygen, water, and pH, which are the most common chemical factors). 660 Joints .... 73 Allowable Stress in Piles ....73 . .593 Application of Zinc-Rich Primers ....594 Measurement and Payment .... 415 Earth Load Bedding Factor for Circular Pipe . 359 PRESERVATIVE TREATMENT ....359 Requirement for Treatment ....359 Treatment Chemicals ....359 Field Treating ....359 . The design slip force should not be exceeded in connections subject to either H or HS truck or lane loading. 610 Bolts and Washers .... 199 ShearFriction .... 578 11.5.6.3 Surface Conditions .... 89 Location of Equivalent Footing after Duncan and Buchignami (1976) .... 601 Weep Holes .... 247 Division I Division I CONTENTS 9.26.1 9.26.2 9.26.3 9.26.4 9.27 9.28 9.29 Minimum Cover ....247 . The area of the concrete slab to be used in this requirement is also defined in the specification as the structural thickness times the entire width of the deck for reasons discussed previously (see the earlier commentary on the revisions to Article 10.38.4.3). The effects of permanent point or line surcharge loads (other than normal traffic live loads) on backslopes shall also be considered in developing the design earth pressures. 535 CONSTRUCTION JOINTS ....535 General .... Reinforcement Type All Steel Reinforcements Geogrids Geotextiles Default Value for 1.O 0.8 0.6 a 152 HIGHWAY BRIDGES life of the wall shall be determined where the reinforcement load is maximum (i.e., at the boundary between the active and resistant zones) and at the connection of the reinforcement to the wall face. 294 10.32.6 10.33 ROLLED BEAMS .... TABLE 5.8.6.1.2A Minimum Requirements for Geosynthetic Products to AUow Use of Default Reduction Factor for Long-Term Degradation Polymer Type Property Polypropylene W Oxidation Resistance . In general, this only applies to gravity and semi-gravity walls. For sections where the neutral axis is not located at the mid-depth of the web, a horizontal design force resultant in the web at the point of splice, H,, shall also be applied at the middepth of the web. .488 . 1999/2000 COMMENTARY DIVISION I1 COMMENTARY TO SECTION 7-EARTH RETAINING SYSTEMS C7.3 MATEIUALS C-137 C11.3.2.1 Material References to the AASHTO M 292 (ASTM A 194) Grades 2 and 2H nuts have been eliminated. 10.32.3.1.2 The effective bearing area of a fastener shall be its diameter multiplied by the thickness of the metal on which it bears. 5.2.2.1 Bearing Capacity The bearing capacity of wall foundation support systems shall be estimated using procedures described in Articles 4.4,4.5, or 4.6, or other generally accepted theories. also be investigated for "over stress cycles produced by placing a single truck on the bridge distributed to the girders as designated in Article 3.23.2 for one traffic lane loadina. (Article 4.6.5.3.1) load transfer factor in the ith interval, nondii. Allowable total and differential vertical deformations for a particular retaining wall are dependent on the ability of the wall to deflect without causing damage to the wall elements or exhibiting unsightly deformations. (1961). 563 lvii lviii CONTENTS 10.12.1 10.12.2 Measurement ....563 Payment . 4.4.8.1 Bearing Capacity 4.4.8.1.1 Footings on Competent Rock The allowable contact stress for footings supported on level surfaces in competent rock may be determined using 20 4.4.8 Figure 4.4.8.1.1A (Peck, et al. 536 Polystyrene Board Fillers .... T or Rev -For all transition radii without the end welds ground smooth. (d) Consideration of geomorphic changes on nearby structures in the vicinity of the proposed structure. A minimum length, L,, in the resistant zone of 0.9 meters (3 feet) shall be used. (Article 4.6.5.5.2) = displacement influnce factor for rocksocketed shafts loaded in uplift, nondim. The effect of compacting backfill in confined areas behind retaining walls may result in development of earth pressures greater than those represented by active or atrest conditions. "Field Testing of a Steel Bridge and a Prestressed Concrete Bridge," Research Project No. 86-05, Final Report, Vol. .223 Welded Splices or Mechanical Connections ....223 Splices of Welded Deformed Wire Fabric in Tension . 635 Division .JI Division I1 CONTENTS 19.5 19.5.1 19.5.2 19.5.3 19.6 INSTALLATION . The width of the footings, however, may vary according to the height of the wall as required by design. The serviceability limit state is not evaluated in current practice for internal stability design. It is acceptable to use "By' in lieu of "L," especially for walls with relatively thick facing units. Passive pressures shall be neglected in stability computations. C10.61 CONSTRUCTIBILITY C10.61.2 An editorial change is made to change the load factor 'y' to the load factor ' 7 ' . 359 Parallel Strand Lumber .... 665 Long-Span Structures .... 78 4.5.21 Timber Piles . 2) Determination of Soil Aggressiveness: Soil aggressiveness for geosynthetics is assessed based on the soil pH, gradation, plasticity, organic content, and inground temperature. The maximum spacing between vertical supporting elements depends on the relative stiffness of the vertical elements and facing, and the type and condition of soil to be supported. . 4.11.6.3 Compaction Monitoring Compaction shall be carried out in a manner so that the fill material within the section under inspection is as close as practicable to uniform. 383 Division I Division I CONTENTS 13.9.3 13.9.4 xxxix Fasteners .... DetourBridges ....488 Haul Bridges ....488 Maintenance ....535 Materials .... (See Article 3.8.1.) Values of y and p coefficients for load factor design, as given in Table 3.22.1A, shall apply to strength limit state considerations; while those for service load design (also given in Table 3.22.1A) shall apply to serviceability considerations. .67 Distribution of Reinforcement ....67 Shear ....67 . 576 ASSEMBLY .... 197 Compression Members .... If epoxy type coatings are used, they should meet the requirements of ASTM A 884 for bar mat and grid reinforcements, or AASHTO M 284 (ASTM D 3963) for strip reinforcements, and have a minimum thickness of 0.41 mm (16 mils). 294 10.34.2.2 Riveted or Bolted Girders .... 637 Installation . 10.34.2.2.2 Width of outstanding legs of flange angles in compression, except those reinforced by plates, shall not exceed the value determined by the formula b' - 1,625 t butinnocaseshall b'lt exceed 12 10.34.2.2.8 The number of fasteners connecting the flange angles to the web plate shall be sufficient to develop the increment of flange stress transmitted to the flange angles, combined with any load that is applied directly to the flange. 562 M i n g of Grout ....562 . 603 Concrete Block .... 348 . When appropriate, information concerning ultimate load capacity, load transfer, lateral load-displacement with depth, the effects of shaft group interaction, the degree of fixity provided by caps and footings, and other data pertinent to the anticipated loading conditions on the production shafts shall be obtained. Steel Piles . .222 Splices of Deformed Bars and Deformed Wire in Tension ....223 Splices of Bars in Compression ....223 Lap Splices in Compression ....223 . Revised Article 10.57.2 (see below) will allow the option to compute overload flange stresses caused by loads acting on the appropriate composite section assuming the concrete deck to be fully effective for both positive and negative moment if certain conditions are met. 236 Steel Stress .... .647 Wire-Enclosed Riprap (Gabions) ....647 Fabrication ....647 Installation ....648 Grouted Riprap ....648 Sacked Concrete Riprap ..... 111 Selection of Wall Type .... Soil Design 345 Pipe-Arch Design ....345 Special Conditions ....345 Construction and Installation . 2.7.1.1.5 Careful attention shall be given to the treatment of railings at the bridge ends. 3 BRIDGELOCATIONS ....3 WATERWAYS ....3 General . Shafts designed for and constructed in expansive soil shall extend for a sufficient depth into moisture-stable soils to provide adequate anchorage to resist uplift. A definition of d,is added without making a distinction between the actual and required spacing, for reasons discussed previously. For tension flanges, the sum of the accumulated factored stresses is not to exceed the maximum strength, F,, of the flange taken equal to F,. End-Bearing Pile-A pile whose support capacity is derived principally from the resistance of the foundation material on which the pile tip rests. Analysis of drilled shafts subjected to cyclic loading may be considered in the COM624 analysis (Reese, 1984). When shafts are constructed in corrosive or marine environments, or when concrete is placed by the water or slurry displacement methods, the clear distance shall not be less than 4 inches for uncased shafts and shafts with permanent casings not sufficiently corrosion resistant. 184 AbutmentTypes .... Potential for reinforcement rupture and pullout are also evaluated at the connection of the reinforcement to the wall facing. 4.3.4 Laboratory Testing Laboratory testing shall be performed as necessary to determine engineering properties including unit weight, shear strength, compressive strength and compressibility. 10.16.10.6 The diameter of fasteners in lacing bars shall not exceed one-third the width of the bar. Preferably, values of C, should be determined from the results of laboratory testing of rock cores obtained within 2B of the base of the footing. Where pile or shaft groups will be used, the subsurface exploration shall extend at least two times the maximum pile group dimension below the anticipated tip elevation, unless the foundations will be end bearing on or in rock. AND WATERWAY OPENINGS .... As a minimum, the written test procedures should include the following: r Apparatus for applying loads including reaction system and loading system. Reinforcement Strength Design . nondim. 5 C, f 126.1 107.0 107.0 90.4 75.7 79.8 10.32.2 289 DIVISION I-DESIGN TABLE 10321A Allowable Stresses- Structural Steel (Jn pounds per square inch) (Continued) Structural Carbon Steel .me High-Strength Low-Alloy Steel Quenched and Tempered Low-Alloy Steel High-Yield Strength Quenched and Tempered a Alloy Steel when KLlr > C, with ES. 77 Point Attachments .... The performance factors for the group capacity calculated using the sum of the individual drilled shaft capacities are the same as those for the single drilled shaft capacities. 202 Required Strength . .I25 Design Criteria for Rigid Retaining Walls, (Coulomb Analysis) .... The stiffener is often located at an inefficient location for a particular condition resulting in a very low bend-buckling web capacity (reflected in a small value of the bend-buckling coefficient k). However, the maximum load applied to any one element need not exceed P, the transverse design load. They should be sent to the Chairman, Subcommittee on Bridges and Structures, AASHTO, 444 North Capitol Street, N.W., Suite 249, Washington, D.C. 20001. 95 Notations . The cell class "0"in ASTM D335 is referred to "unspecified." Instructions for the SP-NCTL test procedure and requirements will be incorporated into the appropriate sections of the Material Specification to guide the user. FIGURE 5.7.2A Guidelines for Estimating Earth Pressure on Walls with %o or More Levels of Anchors Constructed from the Top Down Modified after Tenaghi and Peck (1967) ported, allowable wall deflections, the space between anchors, anchor prestress, and the potential for anchor yield. Connection materials shall be designed to accommodate losses due to corrosion in accordance with Article 5.8.6.1 .l. 484 Formwork Design and Construction .... 77 xv xvi CONTENTS Division I . The design of laterally loaded drilled shafts shall account for the effects of interaction between the shaft and ground, including the number of piers in the group. 174 PART C-STRENGTH DESIGN METHOD LOAD FACTOR DESIGN SCOPE ....174 DEFINITIONS .... 69 Batter Piles .... 401 Guides and Restraints .... 10.24.7 Edge Distance of Fasteners 10.24.7.1 General The minimum distance from the center of any fastener in a standard hole to a sheared or thermally cut edge shall be: For 1-inch fasteners, 1%inches For %-inch fasteners, 1% inches For %-inchfasteners, 1Y4 inches For %-inchfasteners, 1Y8 inches The minimum distance from the center of any fastener in a standard hole to a rolled or planed edge, except in flanges of beams and channels, shall be: For 1-inch fasteners, 1% inches For %-inch fasteners, 1% inches For %-inchfasteners, 1%inches For %-inch fasteners, 1 inch In the flanges of beams and channels the minimum distance from the center of a standard hole to the edge of the flange shall be: For 1-inch fasteners, 1 % inches For %-inchfasteners, 1%inches For Y4-inch fasteners, 1 inch For %-inch fasteners, 7/8 inch The maximum distance from the center of any fastener to any edge shall be eight times the thickness of the thinnest outside plate, but shall not exceed 5 inches. .655 Finishing ....655 Curing and Protecting ....655 MEASUREMENT AND PAYMENT . 5.8.6.2 Allowable Stresses 5.8.6.2.2 Geosynthetic Reinforcements 5.8.6.2.1 Steel Reinforcements The allowable tensile stress for steel reinforcementsand connections for permanent structures (i.e., design lives of 75 to 100 years) shall be in accordance with Article 10.32, in particular Table 10.32.1A. ASTM C 1262 is a newly developed protocol specifically developed for dry-cast concrete blocks, and only just recently has information been available to identify what the acceptance criteria should be when using this protocol. 18,000 Bending in Extreme Fiber .... the external forces resulting from those dead loads should be added t o the earth pressure force3 shown above by superposition (see Figure 5.8.12.1C). 10.25.2 Location of Pins Pins shall be so located with respect to the gravity axis of the members as to reduce to a minimum the stresses due to bending. 160 Design of Stiff or Rigid Concrete, Steel, and Timber Facings ......160 Design of Flexible Wall Facings .... 176 Movement Under Serviceability Limit States . However, within specific limits of wall application, soil conditions, and polymer type, strength degradation due to these factors can be anticipated to be minimal and relatively consistent from product to product, and the impact of any degradation which does occur will be mini- 155 m mal. Ashlar Masonry ....597 MATERIALS .... 2.4 HIGHWAY CLEARANCES FOR UNDERPASSES HORIZONTAL CLEARANCE zk- 0 - 1 ROADWAY WIDTH 0 FIGURE 2.3.1 Clearance Diagram for Bridges limits of structure costs, type of structure, volume and design speed of through traffic, span arrangement,skew, and terrain make the 30-foot offset impractical, the pier or wall may be placed closer than 30 feet and protected by the use of guardrail or other barrier devices. Protective Covers .... For shaft layouts not conforming to these criteria, the effects of shaft interaction shall be considered in the design. If other units are used, the dimensional correctness of the equations should be confirmed. Rail members located more than 5 feet 0 inches above the walkway are excluded from these requirements. Handling Stresses 90 Reinforcement Cover ....90 Reinforcement into Superstructure . A cast-in-place facing has the same vertical deformation limitations as the more rigid retaining wall systems. 520 Earthwork .... Sand -Semi-empirical procedure using SPT data -Semi-empirical procedure using CPT data -Rational methodusing & estimated from SPT data using +f estimated from CPT data b. 510 Testing and Stressing .... 80 4.6.5 Geotechnical Design .... -525 Water .... 75 . Aggregate .... 658 Grouting .... Design guidelines for these cases are provided in FMWA publication No. FHWA SA-96-071"Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines." Compound stability should also be evaluated for these complex MSE wall systems (see Article 5.8.2). 281 FASTENERS (RIVETS AND BOLTS) . Procedures for accomplishing this reduction in seismic load are provided in the AASHTO LRFD Bridge Design Specifications,2nd Edition. THE TWO LOWER DIAGRAMS ARE NOT VALID FOR PERMANENT WALLS OR WALLS WHERE WATER LEVEL LIES ABOVE BOTTOM OF EXCAVATION. 5.6.2 freezing and expansion. 577 11.5.3.3 Check Assembly-Numerically Controlled Drilling ....577 11.5.3.4 Field Welded Connections ....577 Match Marking ....577 11.5.4 Connections Using Unfinished, Turned, or Ribbed Bolts ....577 11.5.5 577 11.5.5.1 General .... 597 597 Ashlar Stone .... Furthermore, ASTM C 666 has more than one testing protocol, neither of which have an identified acceptance criteria. In planning the exploration program, considerationshould be given to placing borings inboard and outboard of the wall line to define conditions in the scour zone at the toe of the wall and in the zone behind the wall to estimate lateral loads and anchorage or reinforcement capacities. The cross frames acting alone in plan with the girders through Vierendeel truss action may be adequate for smaller bridges. 10.30.4 Expansion Joints 10.29.7 Pedestals and Shoes 10.30.4.1 To provide for expansion and contraction movement, floor expansion joints shall be provided at all expansion ends of spans and at other points where they may be necessary. 531 Hot Weather Protection .... = Passive earth pressure coefficient for curved fail- ure surface (dim); (See Article 5.5.2) = Passive earth pressure coefficient for planar failure surface (dim); (See Article 5.5.2) = Depth from concentrated horizontal dead load location that force is distributed (m); (See Article 5.8.12.1) = Length of soil reinforcing elements (m); (See Article 5.8.2); length of structural footings (m); (See Article 5.8.12.1) La = Length of reinforcement in the active zone (m); (See Article 5.8.5.2) Le = Length of reinforcement in the resistant zone (m); (See Article 5.8.5.2) Lei = Effective reinforcement length for layer i (m); (See Article 5.8.9.2) m = Relative horizontal distance of point load from back of wall face (dim); (See Article 5.5.2) MA = The moment about point z at base of segmental concrete facing blocks due to force W, (mkNIm); (See Article 5.8.7.2) = The moment about point z at base of segmental concrete facing blocks due to force WE (mkN1m); (See Article 5.8.7.2) = Relative depth below top of wall when calculating lateral pressure due to point load above wall (dim); (See Article 5.5.2) = Number of reinforcement layers vertically within MSE wall (dim); (See Article 5.8.9.2) = Active earth pressure force (kNIm); (See Article 5.5.2) = Inertial force caused by seismic acceleration of the reinforced soil mass (kN/m); (See Article 5.8.9.1) = Inertial force caused by seismic acceleration of the sloping soil surcharge above the reinforced soil mass (kNlm); (See Article 5.8.9.1) = At-rest earth pressure force (kN/m); (See Article 5.5.2) = Earth pressure force resulting from uniform surcharge behind wall (W m) ; (See Article 5.5.2) = Dynamic horizontal thrust due to seismic loading (kNlm); (See Article 5.8.9.1) = Concentrated horizontal dead load force (kN/m); (See Articles 5.5.2 and 5.8.12.1) = Inertial force of mass within active zone due to seismic loading (kN/m); (See Article 5.8.9.2) = Reinforced wall mass inertial force due to seismic loading (kNIm); (See Article 5.8.9.1) = Resultant horizontal load on wall due to point load (kN/m), (See Article 5.5.2) = Concentrated vertical dead load force for strip load (kN/m); (See Article 5.8.12.1) = Concentrated vertical dead load force for isolated footing or point load (kN/m); (See Article 5.8.12.1) P, = Force due to hydrostatic water pressure behind wall (kN/m); (See Article 5.5.3) live load pressure (kN/m2); (See Article q 5.8.2) = Cone end bearing resistance (kN/m2), (See Artiq, cle 5.3.1) = Line load force (kN/m); (See Article 5.5.2) Qp = Point load force (kN); (See Article 5.5.2) = Resultant of foundation bearing pressure (kN or R kN/m); (See Article 5.8.3) R' = Distance above wall base to resultant of lateral pressure due to surcharge (m); (See Article 5.5.2) R, = Soil reinforcement coverage ratio (dim); (SeeArticle 5.8.6) RF = Reduction factor applied to the ultimate tensile strength to account for short and long-term degradation factors such as installation damage, creep, and chemical aging (dim); (See Article 5.8.6.1.2) RF, = Reduction factor applied to the ultimate tensile reinforcement-facingconnection strength to account for long-term degradation factors such as creep and chemical aging(dim);(See Article 5.8.7.2) RF, = Reinforcement strength reduction factor to account for installation damage (dim); (See Article 5.8.6.1.2) RFcR= Reinforcement strength reduction factor to account for creep rupture (dim); (See Article 5.8.6.1.2) = Reinforcement strength reduction factor to account for rupture due to chemical/biological degradation (dim); (See Article 5.8.6.1.2) = Equivalent soil surcharge height above wall (m); S (See Article 5.8.4.1) Sh = Horizontal reinforcement spacing of discrete reinforcements (mm);(See Article 5.8.6) S, = The reinforcement strength needed to resist the static component of load (kN/m); (See Article 5.8.9.2) S, = The reinforcement strength needed to resist the dynamic or transient component of load (kNIm); (See Article 5.8.9.2) St = Transverse grid element spacing (mm); (See Article 5.8.5.2) = Vertical spacing of soil reinforcement (mm); (See S, Article 5.8.4.1) = Transverse grid or bar mat element thickness t (mm);(See Article 5.8.5.2) T = Total load applied to structural frame around obstruction (kN); (See Article 5.8.12.4) T, = The allowable load which can be applied to each soil reinforcement layer per unit width of reinforcement (kN/m); (See Article 5.8.6) T, = The allowable load which can be applied to each soil reinforcement layer per unit width of rein= Traffic 120 HIGHWAY BRIDGES forcement at the connection with the wall face (W m) ; (See Article 5.8.7.2) T, = Maximum load applied to each soil reinforcement layer per unit width of wall (kN/m); (See Article 5.8.4.1) = Allowable long-term reinforcement tension per Td unit reinforcement width for ultimate limit state (kN/m); (See Article 5.8.6.1.2) Tlot = The ultimate wide width tensile strength for the reinforcement material lot used for connection strength testing (W m) ; (See Article 5.8.7.2) Tmd = Incremental dynamic inertia force at level i (kN/m of structure); (See Article 5.8.9.2) To = Applied reinforcement load per unit width of wall at the connection with the facing (kNm); (See Article 5.8.4.2) T,, = The peak load per unit reinforcement width in the connection test at a specified confining pressure where reinforcement pullout is known to be the mode of failure W m) ; (See Article 5.8.7.2) Tmd = The total static plus seismic load applied to each reinforcement layer per unit width of wall (KNJm); (See Article 5.8.9.2) = Ultimate tensile strength of geosynthetic reinTdt forcement per unit reinforcement width (kN/m); (See Article 5.8.6.1.2.) Tdtc = The peak load per unit reinforcement width in the connection test at a specified confining pressure where reinforcement rupture is known to be the mode of failure (kNIm); (See Article 5.8.7.2) V1 = Weight of reinforced soil mass (W m) ; (See Article 5.8.2) V2 = Weight of sloping soil surcharge on top of reinforced soil mass W m) ; (See Article 5.8.2) W = Weight of reinforced wall mass (kN/m); (See Article 5.8.9.1) W, = Weight of facing blocks outside the heel of the base unit (kN/m); (See Article 5.8.7.2) WB = Weight of facing blocks inside the heel of the base unit within hinge height (W m) ; (See Article 5.8.7.2) Ww = Weight of facing blocks over the base unit (kN/m); (See Article 5.8.7.2) W, = Width of wall facing or facing blocks (mm); (See Article 5.8.7.2) X1 = Horizontal distance of concentrated dead load fromPointO toeofwall(m); (SeeArticle5.8.12.1) Z = Depth below effective top of wall or to reinforcement (m); (See Article 5.8.4.1 or 5.8.12.1) = Depth to reinforcement at beginning of resistant Z, zone for pullout computations (m); (See Article 5.8.4.1) 5.4 Z2 = Depth where effective surcharge width D, inter- a = Scale effect correction factor (dim); (See Article p = Inclination of ground slope behind wall measured sects back of wall face (m); (See Article 5.8.12.1) 5.8.5.2) counterclockwise from horizontal plane (deg); (See Article 5.5.2) 6 = Friction angle between two dissimilar materials (deg); (See Article 5.5.2) 6- = Maximum lateral wall displacement occurring (See Article 5.8.10) during wall construction (mm); SR = Relative lateral wall displacement coefficient (dim); (See Article 5.8.10) A = Lateral Rotation at top of wall (mm); (See Article 5.5.2) Auh = Horizontal stress at the soil reinforcement location resulting from a concentrated horizontal load (kN/m2); (See Article 5.8.12.1) Aavl = Vertical stress at the soil reinforcement location resultingfrom a concentrated vertical load (kN/m2); (See Article 5.8.12.1) = Soil unit weight OcN/m3) y = Soil unit weight for random backfill behind and y, above reinforced backfill (kN/m3); (See Article 5.8.1) y, = Soil unit weight for reinforced wall backfill OcN/m3);(See Article 5.8.4.1) = Effective unit weight of soil or rock (kN/m3) y' = Unit weight of water (kN/m3) yw = Friction angle of the soil (deg); (See Article 5.5.2) = Effective stress angle of internal friction (deg); ' (See Article 5.5.2) = Friction angle of the soil behind the MSE wall re+f inforcements (deg); (See Article 5.8.1 or 5.8.4.1) + = Friction angle of the soil within the MSE wall reinforcement zone (deg); (See Article 5.8.1 or 5.8.4.1) 8 = Inclination of back of wall measured clock-wise from horizontal plane (deg); (See Article 5.5.2) = Soillreinforcement interface friction angle (deg); p (See Article 5.8.2) a2 = Vertical stress due to equivalent horizontal soil surcharge above wall when sloping ground present (kN/m2); (See Article 5.8.4.1) a, = Active pressure on the back of a wall (kN/m2); (See Article 5.5.2) = Horizontal soil stress at the soil reinforcement uh (kN/m2);(See Article 5.8.4.1) a, = Vertical stress on the soil reinforcement (kN/m2); (See Articles 5.8.4.1 and 5.8.5.2) = Horizontal stress due to point load above wall UH (kN/m2); (See Article 5.5.2) + 5.4 o DIVISION I-DESIGN = Wall face batter due to setback per course (deg); 121 5.5.2 Earth Pressure and Surcharge Loadings - (See Article 5.8.5.1) = Inclination of internal failure surface from hori- zontal (deg); (See Article 5.8.5.1) The notations for dimension units include the following: deg = degree; dim = dimensionless; m = meter; mrn = millimeter; kN = kilonewton; and kg = kilogram. The effective design temperature is defined as the temperature which is halfway between the average yearly air temperature and the normal daily air temperature for the highest month at the wall site. Hooked-Bar Tie Requirements . Eccentric connections shall be avoided, if practicable, but if unavoidable the members shall be so proportioned that the combined fiber stresses will not exceed the allowed axial design stress. PART D-STRENGTH DESIGN METHOD LOAD FACTOR DESIGN 10.42 10.43 10.44 10.45 10.46 10.47 10.48 SCOPE .... 10.18.2.1.2 In both flange and web splices, there shall be not less than two rows of bolts on each side of the joint. 94 Nearby Structures . In the above b is the flange plate width, t is the thickness, and fb is the calculated maximum compressive bending stress. 8 Curbs ....8 HIGHWAY CLEARANCES FOR TUNNELS ....8 Roadway Width ....8 Clearance between Walls ....10 Vertical Clearance .... Zandonini,R. There is no known theoretical reason for using the subpanel depth in this requirement. All steel centering devices shall be epoxy coated. The heading for this LFD article is changed from 'COMPOSITE BEAMS AND GIRDERS' to the more appropriate heading of 'COMPOSITE SECTIONS' since all the provisions in this article apply to 'sections'. 287 Concrete Deck Panels .... Stress: uv= CZ + q + bv Pullouu uv= 7,. 198 Shear in Lightweight Concrete .... uaerr. 620 18.4.5.1 Elastomer .... The performance factors for side resistance and tip resistance for three analytic methods shall be as provided in Table 4.10.6-3. The diameter of columns supported by shafts shall be less than or equal to B. 604 Copings, Bridge Seats, and Backwalls . :..................543 Erection .... 334 FATIGUE .... The group capacity shall be the lesser of: -the sum of the modified individual capacities of each pile in the group, or -the capacity of an equivalent pier consisting of the piles and a block of soil within the area bounded by the piles. Current ASD specifications contain provisions for the design of flanges stiffened both longitudinally and transversely in Article 10.39.4.4, which can be modified for use with the strength design method. Compressionflange thicknesses are preferably not to be less than 1.5 times the web thickness. The U.S. Department of Transportation is a nonvoting member. For r e l a t r v e l y thlck fecrng elements kg.. 359 Piles .... Refer to Figure 4.6.5.5.2B to determine I,,. MPa (Article 9.20) compressive stress in concrete (after allowance for all prestress losses) at centroid of cross section resisting externally applied loads or at junction of web and flange when the centroid lies within the flange, MPa (In a composite member, f, is resultant compressive stress at centroid of composite section, or at junction of web and flange when the centroid lies within the flange, due to both prestress and moments resisted by precast member acting alone) (Article 9.20) compressive stress in concrete due to effective prestress forces only (after allowance for all prestress losses) at extreme fiber of section where tensile stress is caused by externally applied loads, MPa (Article 9.20) guaranteed ultimate tensile strength of the prestressing steel, ~ , * f :, N. When all requirements of Article 10.48.2.1 are satisfied (including the lateral bracing requirement), the maximum strength, F,, of the tension flange is taken equal to F, and the maximum strength, F,, of the compression flange is taken equal to Fc,Rb. F,, represents a critical compression-flange local buckling stress, which is determined based on the actual slenderness of the compression flange as specified in Article 10.48.2 and cannot exceed Fy.Therefore, a compression flange with a larger slenderness (up to the limiting value of 24 specified in Article 10.48.2.1(a)) can be used at more lightly loaded sections. Notations . Uplift capacity of straight-sided drilled shafts shall rely only on side resistance in conformance with Article 4.13.3.3.2 for drilled shafts in cohesive soils, and Article 4.13.3.3.3 for drilled shafts in cohesionless soils. C10.38 COMPOSITE GIRDERS C10.38.1 General Language is added to indicate that concrete on the tension side of the neutral axis can also be considered for computing fatigue stress ranges and fatigue shear ranges in ASD as permitted under the revised provisions of Articles 10.3.1 and 10.38.5.1 (see the Commentary discussion related to those articles). In general, if vertical deformations are properly controlled, horizontal deformations will likely be within acceptable limits. 4.9 Nominal Resistance-The analytically estimated loadcarrying capacity of a foundation calculated using nominal dimensions and material properties, and established soil mechanics principles. 473 Pier Requirements . C10.57.1 Noncomposite Sections This revised article limits the maximum overload flange stress at noncomposite sections (versus girders) to 0.8F,. 4.4.8.2 Settlement For circular (or square) footings; 4.4.8.2.1 Footings on Competent Rock For footings on competent rock, elastic settlements will generally be less than % inch when footings are designed in accordance with Article 4.4.8.1.1. When elastic settlements of this magnitude are unacceptable or when the rock is not competent, an analysis of settlement based on rock p = qo(1 - v2),, with I, = (G)/P, (4.4.8.2.2-1) For rectangular footings; TABLE 4.4.8.1.2A Values of Coefficient N, for Estimation of the Ultimate Bearing Capacity of Footings on Broken or Jointed Rock (Modified after Hoek, (1983)) Rock Mass Quality General Description RMR") Rating - NGI(~)

RQD'~) Rating (%) A B N,(4) C D E Excellent Intact rock with joints spaced > 10 feet apart 100 500 95-100 3.8 4.3 5.0 5.2 6.1 very good Tightly interlocking, undisturbed rock with rough unweathered joints spaced 3 to 10 feet apart. CONSTRUCTION 646 ....151 M i m u m Requirements for Geosynthetic Products to Allow Use of Defaulted Reduction Factor for Long-Term Degradation ....156 Default of Minimum Values for the Total Geosynthetic Ultimate Limit State Strength Reduction Factor, RF ... 161 Externalstability ....426 Trench Installations ....426 Distribution of Concentrated Load Effects in Slabs and Bottoms ....426 Distribution of Concentrated Loads in Skewed Culverts ....427 Span Length .... Note: Equation (10-18) has been removed. PAYMENT .... The eccentricity of loading evaluated using factored loads shall not exceed ?/s (37.5%) of the footing dimensions in any direction. 281 nor inspected to the requirements of Article 11.5.6.4.9, Division 11, but shall be tightened to the full effort of a man using an ordinary spud wrench. Instants, other environmental conditions which are defined as aggressive as described in Division 11, Article 7.3.6.3, or where deicing spray is anticipated. The table also refers back to the upper blt limit given in Article 10.48.2.1(a).The current Dlt, limits in the table are removed since Equation (10-100) has been eliminated for reasons discussed previously. T or Rev -For all transition radii with unequal plate thickness and reinforcement not removed. 331 Flange Plates .... E 725 HIGHWAY BRIDGES Section 8 REINFORCED CONCRETE NOTATIONS = depth of equivalent rectangular stress block, mm (Article 8.16.2.7) = depth of equivalent rectangular stress block for balanced strain conditions, mm (Article 8.16.4.2.3) = shear span, distance between concentrated load and face of support, mm (Articles 8.15.5.8 and 8.16.6.8) = effective tension area of concrete m u m d' i g the flexural tension reinforcement and having the same cadmid as that reinforcement, divided by the number of bars or wires, mm2; when the flexural reinforcement consists of several bar sizes or wires, the number of bars or wires shall be computed as the total area of reinforcement divided by the area of the largest bar or wire used. 55 4.4.7.1.1.7 Layeredsoils .... 4.11.4.1.2 Semi-empirical Procedures The bearing capacity of foundation soils may be estimated from the results of in-situ tests or by observing foundations on similar soils. r Procedures for loading including reaction loads, load cycling and maximum load. Driving of Test Piles . 515 MATERIALS .... 216 Spacing of Shear Reinforcement ....216 SHRINKAGE AND TEMPERATURE REINFORCEMENT ....216 SPACING LIMITS FOR REINFORCEMENT ....248 Bundling ....248 Size of Ducts ....460 Minimum Support Length Requirements for Seismic Performance Category B ....460 FOUNDATION AND ABUTMENT DESIGN REQUIREMENTS FOR SEISMIC PERFORMANCE CATEGORY B ....460 460 General ....658 SECTION 26-METAL CULVERTS GENERAL .... 10.32.3.3.4 Where rivets or high-strength bolts are subject to both shear and tension, the tensile stress shall not exceed the value obtained from the following equations: for FvFv ≤ 0.33 Fi = F, (10-16) for FvFv > 0.33 where fv = computed rivet or bolt shear stress in shear, ksi; Fv = allowable shear stress on rivet or bolt from Table 10.32.3A or Table 10.32.3B, ksi; Ft = allowable tensile stress on rivet or bolt from Table 10.32.3A or Table 10.32.3B, ksi; Fi = reduced allowable tensile stress on rivet or bolt due to the applied shear stress, ksi. 433 WallArea .... Development of an active state of stress in the soil behind a rigid wall requires an outward rotation of the wall about its toe. 577 11.5.5.3 Ribbed Bolts ....377 . • 5.8.6 Reinforcement Strength Design The strength of the reinforcement need not be checked for buckling; for internal stability, to resist the load applied throughout the design HIGHWAY BRIDGES 150 5.8.6.7 tan B x 0.3H, +H+ 1 - 0.3 tan B Zone of maximum stress potential d f er lure surf ece ---- "If well fncm m bottommd, en d f e r e t o f 0.3H1 ts st11 l required. Thus, this revision also limits the minimum value of k to 7.2, which is approximately equal to the theoretical bend-buckling coefficient for a web plate under uniform compression assuming fixed boundary conditions at the flanges (Reference 7). Also, although a member may be adequately braced, the bracing may not be located directly at the particular section under investigation. .271 . For the conditions where there is no or one anchor level, the magnitude and distribution of lateral resisting forces for embedded vertical elements in soil or rock shall be determined following procedures described in Article 5.6.2. When two or more levels of anchors have been installed, the magnitude of lateral resistance provided by embedded vertical elements will depend on the element stiffness and deflection under load. .542 . 2.4.2 Vertical Clearance A vertical clearance of not less than 14 feet shall be provided between curbs, or if curbs are not used, over the entire width that is available for tr c. 10.24.1.4 Joints required to resist shear between their connected parts are designated as either slip-critical or bearing-type connections. 184 Full-Depth Abutment .... (Articles 4.6.5.1.1 and 4.6.5.1.2) = distance from shaft tip to top of weak soil layer, m (Article 4.6.5.2.4.3) = depth interval, mndim. 441 . 349 Aluminum Structural Plate Pipe, Pipe-Arch. 4.6.5.6.1.4 Group Action There is no reliable rational method for evaluating the group action for closely spaced, laterally loaded shafts. 517 Foundation Treatment .... and B. - 113 Typical Rigid Gravity, Semi-Gravity Cantilever, Nongravity Cantilever, and Anchored Walls Walls Retaining For potential flooding heights, the minimum depth of exploration may be estimated by linear interpolation as a function of L between depths of 2B and 5B below the bearing level. 283 Minimum Clear Distance Between Holes . Footings shall be constructed so as to neither pose an obstacle to water traffic nor be exposed to view during low flow. In particular, there is a potential for anchor damage due to settlement of backfill and underlying soils or due to improperly controlled backfilling procedures. v, = 1(2V + V,) V, = 1(2L:534t+ 664) = 399 kips 1999/2000 COMMENTARY SPLICE-DESIGN REQUIREMENTS Moment Due to Eccentricity of Vw: where e = distance from the centerline of the splice to the centroid of the connection on the side of the joint under consideration Example - Web Splice (cont'd) C-113 HIGHWAY BRIDGES C-114 - E x a m ~ l e Web S ~ l i c e(cont'd) Where splice is on an area of stress reversal: CASE 1: For positive flexure: -11.14 ksi Fcubot, 649 . ...28 Force of Ice on Piers ....582 SECTION 13-PAINTING Table 13.2.1 Untitled ....629 Performance Criteria ....549 Uncoated Reinforcing Steel ....549 Epoxy-Coated Reinforcing Steel ....549 Stainless Steel Reinforcing Bars ....549 Mill Test Reports ....549 BAR LISTS AND BENDING DIAGRAMS ....549 FABRICATION ....550 550 Bending .... 4.3.3 Minimum Coverage A minimum of one soil boring shall be made for each substructure unit. 20 TRAFFICLANES .... 75 . 10.32.5 Cast Steel, Ductile Iron Castings, Malleable Castings, and Cast Iron 10.32.5.1 For cast steel conforming to specifications for Steel Castings for Highway Bridges, AASHTO M 192 (ASTM A 486), Mild-to~-edimStrength Carbon-Steel Castings for General Application, AASHTO M 103 (ASTM A 27), and Corrosion-Resistant Iron-Chromium, Iron-Chromium-Nickel and NickelBased Alloy Castings for General Application, AASHTO M 163 (ASTM A 743), and for Ductile Iron Castings (ASTM A 536), the allowable stresses in pounds per square inch shall be in accordance with 10.32.5.1A. Therefore, determine the long-term geosynthetic connection strength, T,, on a load per unit reinforcement width basis as follows: If the failure mode for the connection is rupture, 160 HIGHWAY BRIDGES 5.8.7.2 mine the minimum overlap length required, but in no case shall the overlap length be less than 1.0 meter (3.3 feet). 69 Test Piles .... Thus, it is indicated that the depth of the web in compression D, relative to DI2 instead be used to determine which value of k should be used in Equation (10-106) to design the web. front of walls founded on slopes. strips) use Ten reinforcement i n t e r f a c e f r i c t i o n angle. .636 . .640 .. FIGURE 5.8.4.1B Calculation of Vertical Stress for Sloping Backslope Condition for Internal Stability Design Since the Rankine method cannot account for wall face batter or the effect of concentrated surcharge loads above the reinforced backfill zone, the Coulomb method shall be used for walls with extensible reinforcement in cases of significant batter (defined as 10° from vertical or more) and concentrated surcharge loads to determine the location of the zone of maximum stress. Equation (10-173) in Article 10.61.1 is used to make the check. Cement, aggregate. Load Fraction = u 5.25.2 Plank and Nail Laminated Longitudinal Flooring 3.25.2.1 In the direction of the span, the wheel load shall be distributed over 10 inches. Where permanent steel casing is used and the shell is smooth pipe and more than 0.12 inch in thickness, it may be considered as load carrying in the absence of corrosion. 425 16.6.4.2.1 Embankment Installations . 587 . 281 Division I Division I CONTENTS Fillet Weld End Returns ....218 . 418 Bedding Factors for Circular Pipe ....669 CementMortar .... 5.5.6.2 Wall Stems The upright stems of cantilever walls shall be designed as cantilevers supported at the base. 213 Transverse Deck Slab Reinforcement in T-Girders andBoxGirders . The level and extent of corrosion protection shall be a function of the ground environment and the potential consequences of an anchor failure. However, an MSE wall with a cast-in-place facing can be specified with a waiting period before the cast-in-place facing is constructed so that vertical (as well as horizontal) deformations have time to occur. 359 General ....359 359 Laminated Veneer~Lumber .... 4.12.3.3.8 Lateral Load For piles subjected to lateral loads, the pile heads shall be fixed into the pile cap. 532 533 Superstructures .... In general, the pseudostatic approach developed by Mononobe-Okabe may be used to estimate the equivalent static forces. .560 Concrete Strength .... .560 Prestressing Equipment .... In general, for walls which do not utilize deep foundation support, subsurface explorations shall extend below the anticipated bearing level a minimum of twice the total wall height. 61 4.4.7.2.5 Tolerable Movement .... Some methods used for estimating settlement of footings on sand include an integral method to account for the effects of vertical stress increase variations. and 10.51.5.1) = thickness of a flange angle, mm (Article 10.34.2.2) = thickness of the web of a channel, mm (Article 10.38.5.1.2) = thickness of stiffener, mm (Article 10.48.5.3) = thickness of flange member to be stiffened, mm (Article 10.56.3.2) = thickness of the flange, mm (Articles 10.20.2.1, 10.37.3, 10.55.3 and 10.39.4.3) = thickness of the concrete haunch above the beam or girder top flange, mm (Article 10.50.1.1.2) = thickness of stiffener, mm (Article 10.37.2 and 10.55.2) = slab thickness, mm (Articles 10.38.5.1.2, 10.50.1.1.1, 10.50.1.1.2) = web thickness, mm (Articles 10.15.2.1, 10.34.3, 10.34.4, 10.34.5, 10.37.2, 10.48, 10.49.2, 10.49.3, 10.55.2, and 10.56.3) = thickness of top flange, mm (Article 10.50.1.1.1) = thickness of outstanding stiffener element, mm (Articles 10.39.4.5.1 and 10.51.5.5) = shearing force, N (Articles 10.35.1, 10.48.5.3, 10.48.8, and 10.51.3) + + + = shear yielding strength of the web, N (Article 10.48.8 and 10.53.1.4) = range of shear due to live loads and impact, N (Article 10.38.5.1.1) = maximum shear force, N (Articles 10.34.4, 10.48.5.3, 10.48.8, and 10.53.1.4) = vertical shear, N (Article 10.39.3.1) = design shear for a web, N (Articles 10.39.3.1 and 10.51.3) = wind loading along exterior flange, N/mm (Article 10.20.2.1) = length of a channel shear connector, mm (Article 10.38.5.1.2) = roadway width between curbs or barriers if curbs are not used, mm (Article 10.39.2.1) = fraction of a wheel load, nondimensional (Article 10.39.2) = length of a channel shear connector measured in a transverse direction on the flange of a girder, mm (Article 10.38.5.1.2) = mass density of concrete, kg/m3 (Article 10.38.5.1.2) = width of flange between longitudinal stiffeners, mm (Articles 10.39.4.3, 10.39.4.4, and 10.51.5.4) = ratio of web plate yield strength to stiffener plate yield strength, nondimensional (Articles 10.34.4 and 10.48.5.3) = distance from the neutral axis to the extreme outer fiber, mm (Article 10.15.2.1) = section modulus, mm3 (Articles 10.48.1, 10.53.1.1, and 10.54.2.1) = allowable range of horizontal shear on an individual connector, N (Article 10.38.5.1.1) = constant based on the number of stress cycles, nondimensional (Article 10.38.5.1.1) = minimum specified yield strength of the web divided by the minimum specified yield strength of the tension flange, nondimensional (Articles 10.40.2 and 10.40.4) = area of the web divided by the area of the tension flange, nondimensional (Articles 10.40.2 and 10.53.1.2) 758 X HIGHWAY BRIDGES = parameter in bearing capacity reduction P = 8 + $ = = equation, (Article 10.48.4) F,,/F,, nondimensional (Article 10.53.1.2) angle of inclination of the web plate to the vertical (Articles 10.39.3.1 and 10.51.3) ratio of total cross sectional area to the cross sectional area of both flanges, nondimensional (Article 10.15.2) distance from the outer edge of the tension flange to the neutral axis divided by the depth of the steel section, nondimensional (Articles 10.40.2 and 10.53.1.2) a n d -b' = C end load cumber at any point, An = d = d = C = area (Article 10.15.3) maximum value of , mm (Article 10.15.3.) reduction factor, nondimensional (Article 10.38.5.1.2, 10.56.1.1, and 10.56.1.3) longitudinal stiffener coefficient, nondimensional (Article 10.39.4.3 and 10.51.5.4) slip coefficient in a slip-critical joint, nondimensional (Article 10.57.3) AP Press. These MSE wall specifications also assume that inex- 660 Bedding and Backfill Materials .... This shall be considered when assessing the design temperature, especially for wall sites located in warm, sunny climates. 148 HIGHWAY BRIDGES Zp= 5.8.5.1 depth o f soil a t reinforcement layer a t beginning of resistant zone, for pullout calculations Any Leve I n Wall 25H Max Stress: 6 = %L TanB cr, = yZ + H L (T a n B 1 Yr with K a determined using a slope angle of 0°. 232 Prestressing Steel .... An editorial revision to this article clarifies that negative-moment support sections must qualify as compact in order to invoke the permissible 10% redistribution C-125 of those elastic support moments to more lightly loaded positive moment sections at Overload and Maximum Load. 202 Design Strength . 50 4.4.7.1.1 Factors Affecting Bearing Capacity .... 88 Iuuiii t x i v Figure 4.6.5.5.1B Figure 4.6.5.5.2A Figure 4.6.5.5.2B Figure 4.12.3.2.1-1 Figure 5.2A Figure 5.2B Figure 5.2C Figure 5.5.1A Figure 5.5.2A Figure 5.5.2B Figure 5.5.2C Figure 5.5.2D Figure 5.5.2E Figure 5.6.2A Figure 5.6.2B Figure 5.6.2C Figure 5.6.2D Figure 5.7.1A Figure 5.7.2A Figure 5.8.1A Figure 5.8.1B Figure 5.8.2A Figure 5.8.2B Figure 5.8.2C Figure 5.8.3A Load Transfer in Tip Bearing Versus Settlement Drilled Shafts (after Reese and O'Neill 1988) .... 88 Influence Chart for Vertical Stress Beneath Rock, Rock-socketed Drilled Shafts, Modied after P e u and rinner (1979) ... 4 Hydraulic Analysis . Rings with circular cross-sections . The nominal dimensions for each type hole shall be not greater than those shown in Table 10.24.2, except as may be permitted under Division I I, Article 11.4.8.1.4. 10.24.2.1 In the absence of approval by the Engineer for use of other hole types, standard holes shall be used in high-strength bolted connections. Mu in Article 10.48.4.1 includes the flange-stress reduction factor Rb For consistency, when computing the moment gradient correction factor Cb in Article 10.48.4.1, the smaller and larger end moments should be used taken at the end of the unbraced segment of the beam are to be substituted for the smaller and larger end moments Ml and M2, respectively. l., "Development of Design Procedures for Steel Girder Bolted Splices," Ph.D. Dissertation, The University of Texas at Austin, December 1995. 403 General . 16.1.2 Notations . Anchored walls have been successfully used to support fills; however, certain difficulties arising in fill wall applications require special consideration during design and construction. Methods .... 4.12.3.3.5 Pile Load Test The load test method specified in ASTM D 1143-81 may be used to verify the pile capacity. Zp 1 2 + S 1s the t o t a I height o f the wall a t the face. The performance factor for the axial compressive capacity, axial uplift capacity and lateral capacity obtained from pile load tests shall be as provided in Table 4.10.6-2. In spans more than 300 feet long, allowance shall be made for expansion and contraction in the floor. The end panel lateral bracing shall be attached to the main trusses or girders and also to the end struts. 277 10.18.4 Tension Members 10.18.4.1. As a minimum, splices in tension members shall be proportioned for a design force, P,, equal to the allowable design strength specified in Article 10.18.1.1 times the effective area of the member, A,, defined as follows: where: A, = net section of the member computed as specified in Article 10.16.14 = p 0.0 for AASHTO M 270 Grade 100/100W (ASTMA709 Grade 100/100W)steels, or when holes exceed 1 % inch in diameter = 0.15 for all other steels and when holes are less than or equal to 1%inch in diameter. 135. The allowable stresses shall be as set forth in Article 10.32. 531 General .... Load Factor Design-capacity modification factor, ...434 Flexibility Factor ....434 Minimum Cover .... .44 Bearing Capacity Factors . or culvert untrenched on yielding foundation ...181 Culvert untrenched on unyielding foundation ....181 FOOTINGS .... The upper limit on blt of 16 currently specified in Article 10.34.4.10 is retained for lightly loaded stiffeners. The allowable anchor capacity for small diameter anchors may be estimated by multiplying the ultimate anchor capacity per unit length times the bonded (or stressing) length and dividing by a FS of 2.5 for anchors in soil and 3.0 for anchors in rock. 26 CurbLoading . 456 Multimode Spectral Analysis ....456 Combination of Mode Forces and Displacements ....456 TIME HISTORY METHOD-PROCEDURE 4 . 465 Modified Design Forces for Foundations ....465 Forces Resulting from Plastic Hinging in the Columns, Piers, or Bents ....466 Division I-A CONTENTS Single Columns and Piers .... 4.3.2 --- DIVISION I-DESIGN Where substructure units will be supported on deep foundations, the depth of the subsurface exploration shall extend a minimum of 20 feet below the anticipated pile or shaft tip elevation. SF ....347 Load Factor Design-capacity modification factor. 10.8.3 It should be noted that there are other provisions in this section pertaining to thickness for fillers, segments of compression members, gusset plates, etc. Consideration should be given to appearance, safety and freedom of view from passing vehicles. 10.32.3 Fasteners (Rivets abd Bolts) Allowable stresses for fasteners shall be as listed in Tables 10.32.3.A and 10.32.3.B, and the allowable force on a slip-critical connection shall be as provided by Article 10.32.3.2.1. 10.32.3.1 General 10.32.3.1.1 In proportioning fasteners for shear or tension, the cross-sectional area based upon the nominal diameter shall be used except as otherwise noted. 4.4.1.4 Footings in Sloped Portions of Embankments The earth pressure against the back of footings and columns within the sloped portion of an embankment shall be equal to the at-rest earth pressure in accordance with Article 5.5.2. The resistance due to the passive earth pressure of the embankment in front of the footing shall be neglected to a depth equal to a minimum depth of 3 feet, the depth of anticipated scour, freeze thaw action, andlor trench excavation in front of the footing, whichever is greater. 314 RibsandBeams .... ;........152 Geosynthetic Reinforcement ....155 . .626 Special Fabrication Requirements for Bronze and Copper Alloy Bearings .... Where the practical The horizontal clearance shall be the clear width and the vertical clearance the clear height for the passage of vehicular traffic as shown in Figure 2.5. Unless otherwise provided, the several parts of the structures shall be constructed to secure the following limiting dimensions or clearances for traffic. The superelevation of the floor surface of a bridge on a horizontal curve shall be provided in accordance with 1.8 FLOOR SURFACES All bridge floors shall have skid-resistant characteristics. (b)Slopinq backf ~ 1 condrtron 1 FIGURE 5.8.9.1A Seismic External Stability of a MSE Wall 5.8.9.2 5.8.9.2 DIVISION I-DESIGN 163 Internal Stability Lei Tmd= Pi 7 Reinforcements shall be designed to withstand horizontal forces generated by the internal inertial force (PI) in addition to the static forces. Foundation displacement analyses shall be based on the results of in-situ and/or laboratory testing to characterize the load-deformation behavior of the foundation soils. 530 530 For Acceptance of Concrete .... See also CI 0.48.1 (1997). .-189 Notations .... 293 10.32.5.4 BearingonMasonry .... Sampling and Testing .... 620 18.4.5.3 Bond . Table C10.32.3B Allowable Stresses on High-Strength Bolts or Connected Material C10.32.1 Steel 'Ihble C1032.1A Allowable Stresses--Structural Steel (Inpounds per square inch) Language is added to footnote c of Table 10.32.1A regarding the computation of the allowable stress in ASD for concentrically loaded columns. 28 Drift Lodged Against Pier ..... Standard Hooks . When all requirements of Article 10.48.2.1 are satisfied, except for the lateral bracing requirement given by Equation (10-101), the maximum strength, F,, of the compression flange is again taken equal to FcrRb.However, in this case the calculated maximum strength of the compression flange cannot exceed the maximum strength for the limit state of lateral-torsional buckling, which is to be calculated as the limiting stress Mu/Sxc,where Mu and S,, are determined according to the provisions of Article 10.48.4.1 for partially braced members. The maximum resultant force on the eccentrically loaded connection shall not exceed the slip resistance computed from Equation (10-172) with Nb taken equal to 1.O. (10 - 4t) where: F, = design shear stress in the web at the point of splice defined in Article 10.18.2.3.6 D = web depth t, = web thickness 10.18.2.3.8 As a minimum, in cases of the service load design method, web splice plates and their connections shall be proportioned for a design moment at the point of splice, M,, representing the portion of the flexural moment that is assumed to be resisted by the web. HIGHWAY CLEARANCES FOR BRIDGES . To ensure some consistency, this revision also states that the area of the concrete slab to be used in this requirement be defined in the specification as the structural thickness times the entire width of the deck. .217 Tension Lap Splices .... 339 Notations .... 20 HIGHWAY LOADS .... 297 10.34.5 Longitudinal Stiffeners .... 10.32.3.2 The allowable stress in shear, bearing and tension for AASHTO M 164 (ASTM A 325) andAASHT0 M 253 (ASTM A 490) bolts shall be as listed in Table 10.32.3B. 205 Combined Flexure and Axial Load .... 516 CribandCeUularWalls .... 10.29.6.3 Anchor bolts shall be designed to resist uplift as specified in Article 3.17. Clay -Semi-empirical procedure using CPT data -Rational method using shear strength measured in lab tests using shear strength measured in field vane tests using shear strength estimated from CPT data c. 83 4.6.5.2 Factors Affecting Axial Capacity in Soil . Members of the Association are the 50 State Highway or Transportation Departments, the District of Columbia, and Puerto Rico. Yura, J. 415 Direct Design Method for Precast Reinforced Concrete Circular Pipe .... .671 Standard Trench Installations ....672 Trench Beddings, Miscellaneous Shapes .... 4.13.3.3.1 Axial Loading of Drilled Shafts The provisions of Article 4.12.3.3.1 shall apply as applicable. T i e maximum bearing pressure shall not exceed the product of the ultimate bearing capacity multiplied by a suitable performance factor. 518 Soldier Pile Walls ....519 Anchored Sheet Pile and Soldier Pile Walls ....519 General .... 214 Lateral Reinforcement of Flexural Members .... -. .286 Masonry Bearings ....286 Anchor Bolts .... 10.24.3.2 Hardened washers are not required for connections using AASHTO M 164 (ASTM A 325) and AASHTO M 253 (ASTM A 490) bolts except as required in Articles 10.24.3.3 through 10.24.3.7. 10.24.3.3 Hardened washers shall be used under the element turned in tightening when the tightening is to be performed by calibrated wrench method. For guidance in design, refer to Division I-A of these Specifications. Cross frames and diaphragms shall be designed for horizontal wind forces as described in Article 10.21.2. 10.20.2 Stresses Due to Wind Loading When Top Flanges Are Continuously Supported 10.20.2.1 Flanges 10.19.2.3 End connections of stringers and floor beams preferably shall be bolted with high-strength bolts; however, they may be riveted or welded. 10.18.2.1.3 Oversize or slotted holes shall not be used in either the member or the splice plates at bolted splices. 344 Steel Conduits ....344 AluminumConduits . 329 Shear . Kerley WASHINGTON, Jerry Weigel, Tony M. The structural design of galvanized steel soil reinforcements and connections shall be made on the basis of F,, the yield strength of the steel, and the cross-sectional area of the steel determined using the steel thickness after corrosion losses, E,, defined as follows: where ERis the total loss in thickness due to corrosion to produce the expected loss in tensile strength during the required design life. 397 Stability . 3.24.3 Bending Moment Bridge Multi-beam Beam Type Non-voided rectangular beams Rectangular beams with circular voids Box section beams Channel, single- and multi-stemmed tee beams K 0.7 0.8 1 .O The bending moment per foot width of slab shall be calculated according to methods given under Cases A and 2.2 3.24 DISTRIBUTION OF LOADS AND DESIGN OF CONCRETE SLABSQ 3.24.1 Span Lengths (See Article 8.8) 3.24.1.1 F~~simple spans the span length shall be the distance center to center but need not exceed clear span plus thickness of slab. 88 Factors Affecting Laterally Loaded Shafts .... 49 49 4.4.5.4 Piping .... Due to their rigidity, excessive differential settlement can cause HIGHWAY BRIDGES 112 5.2.1.1 CI P CONCRETE OR SHOTCRETE F4Cl NG 7 F r C l NC PANELS MSE WALL VI TH HOOULAR PRECAST CONCRETE FACING PANELS MSE WALL WITH GEOSYNTHETI C RE1NFORCEMNT AN0 CI P CONCRETE OR SHOTCRETE FACING MSE waLL WITH S E G ~ N T A L CONCRETE BLOCK FACI NC FIGURE 5.2A Typical Mechanically Stabilized Earth Gravity Walls cracking, excessive bending or shear stresses in the wall, or rotation of the overall wall structure. > Transition radius r 0 in. For MSE walls with extensible reinforcements, reinforcement serviceability criteria, the wall face batter, and the facing type selected (i.e., the flexibility of the facing) will influence the horizontal deformation criteria required. Vertical wall elements may consist of discrete vertical elements (e.g., soldier or sheet piles, caissons, or drilled shafts) spanned by a structural facing (e.g., wood or reinforced concrete lagging, precast or cast-in-place concrete panels, wire or fiber reinforced shotcrete, or metal elements such as sheet piles). 69 Notations .... 649 Wire-Enclosed Riprap (Gabions) .... 10.32.3.3 Applied Tension, Combined Tension, and Shear 10.32.3.3.1 High-strength bolts preferably shall be used for fasteners subject to tension or combined tension and shear. .544 Test 3-Open Time of Bonding Agent . 627 Definitions .... 531 Rain Protection .... Groove Welded Connections Groove Welded AttachmentsLongitudinally Loadedc Kind of Stress Situation T or Reva T or Rev T or Rev) T or Rev T or Rev T or Rev Base metal at ends of partial length welded coverplates wider T or Rev than the flange without welds across the ends. (b) Structural members and bearing seat widths that are resistant to damage or instability. For ground accelerations greater than 0.45 g, A, would be calculated to be less than A. I€cover plates arc used, the allowable static stress at the point oftheoretical cutoff shall be as determined by the formula. For homogeneous girders, R shall always be taken equal to 1.0. A, = smaller gross flange area on either side of the splice foand R shall be computed using the gross section of the member. SECTION >REMOVAL 2.1 2.2 2.3 2.3.1 2.3.2 2.3.3 2.3.4 2.4 OF EXISTING STRUCTURES DESCRIPTION . Compression in concentrically loaded columns with C, = (2 . 293 10.32.5.1 10.32.5.2 Malleable Castings .... volume divided by the length from center to center of perforations. Center-to-Center Shaft Spacing 91 LoadTesting .... To prevent this anomaly, this revision requires that the k value for a longitudinally stiffened web for the case where dSDc 2 0.4 equal or exceed a value of 9(D/Dc)2,which is the k value for a web without longitudinal stiffeners computed assuming partial rotational restraint from the flanges. 3,000 Direct Compression, Short Columns .... = Nondimensional parameter Nc = tip bearing factor to account for large diameter shaft tip, nondim. 93 Anchorage .... 609 Treated Timber .... STRENGTH OF CONNECTIONS .... 4.6.5.4 Factors of Safety Drilled shafts in soil or socketed in rock shall be designed for a minimum factor of safety of 2.0 against bearing capacity failure (end bearing, side resistance or combined) when the design is based on the results of a load test conducted at the site. The sections of members of longitudinal bracing in each panel shall not be less than those of the members in corresponding panels of the transverse bracing. .688 Field Joints .... In addition, language is added to indicate that the hybrid factor R is to be taken as 1.0 at sections where the stress in both flanges caused by the maximum design load does not exceed the specified minimum yield strength of the web since web yielding is assumed not to occur in this case. 470 Free-Standing Abutments .... Preferably, they shall be connected rigidly to the end floor beam. Therefore, when the web slenderness DJt, is below The name of this article is changed from 'Unbraced Sections' to 'Partially Braced Members' to indicate that all members must be braced. 5.3.4 Laboratory Testing Laboratory testing shall be performed as necessary to deincluding unit weight, te-e engineering natural moisture content, Atterberg limits, gradation, shear strength, compressive strength and compressibility. 385 MOVEMENTS AND LOADS .... 5.8.7.2 Connection Strength for Geosynthetic Reinforcements To evaluate the long-term geosynthetic strength at the connection with the wall facing, reduce T,, using the connectionlseamstrength determined in accordance with ASTM D 4884 for structural (i.e., not partial or full friction) connections. .91 Load Test Method Selection ....91 NOTE: Article Number Intentionally Not Used PART C-STRENGTH DESIGN METHOD LOAD FACTOR DESIGN SCOPE ....91 DEFINITIONS ....92 LIMIT STATES. 4.13.3.2.3b Group Settlement 4.13.3.1.1 Downdrag Loads Downdrag loads shall be evaluated, where appropriate, as indicated in Article 4.12.3.1.3. 4.13.3.1.2 Uplift The provisions of Article 4.12.3.1.4 shall apply as applicable. 78 4.6.1.2 Materials . ;.................. 545 Test &Temperature Deflection of Epoxy Bonding Agent ......545 8.13.7.1.7 Test 74ompression and Shear Strength of Cured Epoxy lv BondingAgent .... E 753 HIGHWAY BRIDGES Section 10 STRUCTURAL, STEEL Note: Please refer to Division I for the most current list of "Notations." NOTATIONS = area of cross section, mm2 (Articles 10.37.1.1, 10.34.4, 10.48.1.1, 10.48.2.1, 10.48.4.2, 10.48.5.3, and 10.55.1) = bending moment coefficient (Article 10.50.1.1.2) = amplification factor (Articles 10.37.1.1 and 10.55.1) = product of area and yield point for bottom flange of steel section, N (Article 10.50.1.1.1) = product of area and yield point of that part of reinforcing which lies in the compression zone of the slab, N (Article 10.50.1.1.1) = product of area and yield point for top flange of steel section, N (Article 10.50.1.1.1) = product of area and yield point for web of steel section, N (Article 10.50.1.1.1) = area of flange, d (Articles 10.39.4.4.2, 10.48.2.1, 10.53.1.2, and 10.56.3) = area of compression flange, mm2 (Article 10.48.4.1) = total area of longitudinal reinfoxing steel at the interior support within the effective flange width, mm2 (Article 10.38.5.1.2) =total area of longitudinal slab reinforcement steel for each beam over interior support, mm2 (Article 10.38.5.1.3) = area of steel section, mm2 (Articles 10.38.5.1.2, 10.54.1.1, and 10.54.2.1) = area of web of beam, mm2 (Article 10.53.1.2) = distance from center of bolt under consideration to edge of plate, mm (Articles 10.32.3.3.2 and 10.56.2) = spacing of transverse stiffeners, mm (Article 10.39.4.4.2) = depth of stress block, mm (Figure 10.50A) a B B b b b b b b b b b' b' bf C C C c' c b = ratio of numerically smaller to the larger end moment (Article 10.54.2.2) = constant based on the number of stress cycles, nondimensional (Article 10.38.5.1.1) = constant for stiffeners (Articles 10.34.4.7 and 10.48.5.3) = compression flange width, mm (Table 10.32.1A and Article 10.34.2.1.3) = distance from center of bolt under consideration to toe of fillet of connected part, mm (Articles 10.32.3.3.2 and 10.56.2) = effective width of slab, mm (Article 10.50.1.1.1) = effective flange width, mm (Articles 10.38.3 and 10.38.5.1.2) = widest flange width, mm (Article 10.15.2.1) = distance from edge of plate or edge of perforation to the point of support, mm (Article 10.35.2.3) = unsupported distance between points of support, mm (Article 10.35.2.7) = flange width between webs, mm (Articles 10.37.3.1, 10.39.4.2, 10.51.5.1, and 10.55.3) = width of stiffeners, mm (Articles 10.34.5.2, 10.34.6, 10.37.2.4, 10.39.4.5.1, and 10.55.2) = width of projecting flange element, angle, or stiffener, mm (Articles 10.34.2.2, 10.37.3.2, 10.39.4.5.1, 10.48.1, 10.48.2, 10.48.5.3, 10.50, 10.51.5.5, and 10.55.3) = width of flange, mm (Article 10.20.2.1) = web buckling coefficient, nondiinsional (Articles 10.34.4, 10.48.5.3, 10.48.8, and 10.50(e)) = compressive force in the slab, N (Article 10.50.1.1.1) = equivalent moment factor, nondimensional (Article 10.54.2.1) = compressive force in top portion of steel section, N (Article 10.50.1.1.1) = bending coefficient, nondimensional (Table 10.32.1A, Article 10.48.4.1) HIGHWA.YBRIDGES = column slenderness ratio dividing elastic and inelastic buckling, nondimensional (Table 10.32.1A) = coefficient about X axis, nondimensional (Article 10.36) = coefficient about the Y axis, nondimensional (Article 10.36) = buckling stress coefficient, nondimensional (Article 10.51 S.2) = clear distance between flanges, mm (Article 10.15.2) = clear unsupported distance between flange components, mm (Articles 10.34.3, 10.34.4, 10.34.5, 10.37.2, 10.48.1, 10.48.2, 10.48.5, 10.48.6, 10.48.8, 10.49.2, 10.49.3.2, 10.50(d), 10.50.1.1.2, 10.50.2.1, and 10.55.2) = distance from the top of the slab to the neutral axis at which a composite section in positive bending theoretically reaches its plastic-moment capacity when the maximum strain in the slab is at 0.003, mm (Article 10.50.1.1.2) = clear distance between the neutral axis and the compression flange, mm (Articles 10.48.2.1@), 10.48.4.1, 10.49.2, 10.49.3 and, 10.50(d)) = moments caused by dead load acting on composite girder, N-mrn (Article 10.50.1.2.2) = distance to the compression flange from the neutral axis for plastic bending, mm (Articles 10.50.1.1.2 and 10.50.2.1) = moments caused by dead load acting on steel girder. Cb = 1.0 for unbraced cantilevers and for members where the moment within a significant portion of the unbraced segment is greater than or equal to the larger of the segment end moments. 194 Box Girders . 559 Admixtures .... 45 + 2' 2 For wells r r t h s Ceca bettor 10' o r morm from the verticel. For calculation purposes, the thickness of the clear concrete cover used to compute shall not be taken greater than 50 mm (Article 8.16.8.4) modulus of elasticity of concrete, MPa (Article 8.7.1) flexural stiffness of wmpression member, N.mm2 (Article 8.16.5.2.7) modulus of elasticity of reinforcement, MPa (Article 8.7.2) average bearing stress in concrete on loaded area, MPa (Articles 8.15.2.1.3 and 8.16.7.1) fc f'8 = overall thickness of member, mm = height of rolled+n transverse deformations = fmin = fr = fs = MPa on deformed reinforcing bar, mm (Article 4 I , 8.16.8.3) = compression flange thickness of I- and T- sections, mm = moment of inertia of cracked section tramformed to concrete, mm4 (Article 4 8.13.3) = effective It 8.13.3) = moment of inertia of gross concrete section I, k 0, moment of inertia for computation of deflection, mm4 (Article about centroidal axis, neglecting reinforcement, mm' = moment of inertia of reinforcement about centroidal axis of member cross section, mm' = effective length factor for compression nondimensional (Article members, 8.16.5.2.3) = additional embedment length at support or at point of inflection, mm (Article 8.24.2.3) td 01 MPa ft (Articles h h = square root of specified compressive stress = MPa f~ 8.15.2.1.1) = specified compressive strength of concrete, f, balanced conditions, = extreme fiber tensile stress in concrete at service loads, MPa (Article 8.15.2.1.1) = specified yield strength of reinforcement, ft = extreme fiber compressive stress in of concrete, where f,' is expressed in MPa. average splitting tensile strength of lightweight aggregate concrete, MPa fatigue stress range in reinforcement, MPa (Article 8.16.8.3) algebraic minimum stress level in reinforcement, MPa (Article 8.16.8.3) modulus of rupture of concrete, MPa (Article 8.15.2.1.1) tensile stress in reinforcement at service loads, MPa (Article 8.15.2.2) = stress in compression reinforcement at 8.16.3.4.3 and 8.16.4.2.3) concrete at service loads, MPa (Article fC' APP. Thus, the revision to this article indicates that the number of longitudinal flange stiffeners preferably shall not exceed two. .456 . Also, AASHTO M 270 Grade HPS70W (ASTM A 709 Grade HPS70W) steel has been added to the list of steels that have the demonstrated ability to reach the plastic moment capacity M,. 566 High-Strength Low-Alloy Structural Steel ....566 High-Strength Low-Alloy, Quenched and Tempered Structural Steel Plate .... 215 General . .40 Distribution of Concentrated Loads for Bending Moment and Shear .... lbmed Bolts,Ribbed Bolts, and Rivets (ASTM A 502 Grades 1 and 2)Governed bv Table 10.32.3A Quenched and tempend alloy steel structural shapes and seamless mechanical t u b i i meeting all mechanical and chemical requirements of A 709 Grades 1W100W except that the s p c c i f i maximum tensile strength may be 140.000 psi for sln~cturalshapes and 145,000 psi for seamless mpanical tubing, shall be wnsidacd as A 709 Grades 1W100W s t d . 10.7.4 Actual unbraced length, L, shall be assumed as follows: For the top chords of half-through trusses, the length between panel points laterally supported as indicated under Article 10.16.12; for other main members, the 10.8.1 Structural steel (including bracing, cross frames, and all types of gusset plates), except for webs of certain rolled shapes, closed ribs in orthotropic decks, fillers, and in railings, shall be not less than 5/16 inch in thickness. A, is defined in Article 10.18.2.2.4 and Fcuis defined as follows: (Ifcu/~I+ @fl) 2 0.75% 2 Mu= maximum bending strength of the section in positive or negative flexure at the point of splice, whichever causes the maximum compressive stress due to the factored loads at the mid-thickness of the flange under consideration My= moment capacity at first yield for the section at the point of splice used to compute Mu.For composite sections, Myshall be calculated in accordance with Article 10.50(c). Preformed Membrane Waterproofing Systems . 76 Splices ....76 Caps .... The 10.34.2.1 DIVISION I-DESIGN width-to-thickness ratio, blt, of flanges subject to tension shall not exceed 24. If the angles are not so connected, only 80% of the net areas shall be considered effective. 396 i- xl CONTENTS Compressive Stress .... 78 4.6.1.6 Battershafts .... .74. Bars shall be as close together as practicable and held against lateral movement, but they shall be so arranged that adjacent bars in the same panel will be separated by at least % inch. Railing configurations that have been successfully tested by full-scale impact tests are exempt from the provisions of this Article. The gusset plates shall be of ample thickness to resist shear, direct stress, and flexure acting on the weakest or critical section of maximum stress. The vertical wall elements shall be designed to resist all horizontal earth pressure, surcharge, water pressure, anchor and seismic loadings as well as the vertical component of the anchor loads and any other vertical loads. 10 General .... use '0' i n lieu of 'La). SUBSTITUTIONS . 111 WALL TYPE AND BEHAVIOR .... 25 Number and Position of Traffic Lane Units ....25 Lane Loads on Continuous Spans ....25 Loading for Maximum Stress .... The guardrail or other device shall be independently supported with the roadway face at least 2 feet 0 inches from the face of pier or abutment. 387 Forces in tlie Structure Caused by ~ e s t r a hoft Movement at the Bearing .... 67 Development Length .... 114 Prefabricated Modular Walls .... 3.26.3 Design The analysis and design of composite wood-concrete members shall be based on assumptions that account for the different mechanical properties of the components. For a composite noncompact girder, dead- and live-load moments due to the factored loads are applied to different sections and should not be directly summed when at elastic stress levels (up to and including F,); that is, the principle of superposition does not apply D -AW 1 t Aft FIGURE 1 199912000 COMMENTARY Rearranging Equation (2) yields: Substituting Equation (3) into Equation (1) and solving for the effective transformed Arcgives: The use of this effective Af, in Equation (10-103b) for Rbis more appropriate for composite sections in positive bending and is more consistent with the original derivation of Rb which results in a less critical value of Rbfor these sections. A clarification is made to indicate that the deflection limit of Ll180 or % inch applies to form work spans of 10 feet or less and the deflection limit of U240 or 3/4 inch applies to form work spans exceeding 10 feet. 627 TESTING AND ACCEPTANCE . Nominal Load-A typical value or a code-specified value for a load. The performance factors for drilled shafts socketed in rock shall be as provided in Table 4.10.6-3. Also, an upper limit on the blt for a tension flange covers the case where the flange may be subject to an unanticipated stress reversal. .286 EndFloorBeams .... Vertical wall movements shall be estimated using conventional settlement computational methods (see Articles 4.4,4.5, and 4.6. For gravity and semi-gravity walls, lateral movement results from a combination of differential vertical settlement between the heel and the toe of the wall and the rotation necessary to develop active earth pressure conditions (see Table 5.5.2A). 40 DISTRIBUTION OF WHEEL LOADS AND DESIGN OF COMPOSITE WOOD-CONCRETE MEMBERS . Language is also added at the end of this article to indicate that if the web slenderness DJt, for the singly symmetric section exceeds the upper limit given by Equation (10- 120), either the section must be modified to comply with the limit or else longitudinal stiffeners must be provided. All shafts should be sized in 6-inch increments with a minimum shaft diameter of 18 inches. 184 Scour .... 10.27 EYEBARS 10.27.1 Thickness and Net Section Eyebars shall be of a uniform thickness without reinforcement at the pin holes. For footings on less competent rock, more detailed investigations and analyses shall be performed to account for the effects of weathering, and the presence and condition of discontinuities. 600 Headers .... Thus, the current ASD constructibility check applies 1.4 (1.8211.3) times more dead load. a. .400 Resistance to Deformation ....400 Bronze or Copper Alloy Sliding Surfaces ....400 Materials .... Furthermore, the difference in the environment occurring immediately behind the wall face relative to the environment within the reinforced backfill zone and its effect on the long-term durability of the reinforcement/connectionshall be considered when determining Tac. .638 . In cases where the groundwater table is at a depth less than 1.5 times the footing width below the bottom of the footing, reduction of bearing capacity, as a result of submergence effects, shall be considered. 4.11.4.2 Bearing Capacity of Foundations on Rock The bearing capacity of footings on rock shall consider the presence, orientation and condition of discontinuities, weathering profiles and other similar profiles as they apply at a particular site, and the degree to which they shall be incorporated in the design. .405 Section Properties for Four-Flange Liner Plate . .640 Inspection and Delivery ....640 SURFACE PREPARATION ....640 APPLICATION .... 10.18.1.2 Fillers 10.18.1.2.1 For fillers % inch and thicker in bolted or riveted axially loaded connections, including girder flange splices, additional fasteners shall be required to distribute the total stress in the member uniformly over the combined section of the member and the filler. 435 Smooth wall PVC pipe requirements .... General .... Therefore, F, represents a critical compression-flange local buckling stress, which cannot exceed F,. Working Drawings ....543 Materials and Manufacture ....543 Curing ....543 Storage and Handling .... 35 Case A-Main Reinforcement Perpendicular to Traffic 36 (Spans 2 to 24 Feet Inclusive) .... 467 Connection Design Forces .... Also, anchors should not be located within soft clays and silts, as it is difficult to obtain 114 5.2.1.3 HIGHWAY BRIDGES Mortar Rubble Ya8OnrY Riaid Cravlty wall Reinlorced Concrete Counterfort Semi-Cravlty Wall Reinlorced Concrete Cantilever Semi-Gravlty Wall Slurry or Cyllnder Pile Non-armvity Cantilever Wall NCHOR ZONE FIGURE 5.2C mica1 Rigid Gravity, Semi-Gravity Cantilever, Nongravity Cantilever, and Anchored Walls adequate long-term capacity in such materials due to creep. .221 SECTION 9-PRESTRESSED CONCRETE Figure 9.16.2.1.1 Mean Annual Relative Humidity ....235 SECTION 1eSTRUCTURAL STEEL Figure 10.3.1C Illustrative Examples .... Where required, additional lateral resistance shall be provided by drilling and grouting steel dowels into the rock surface rather than blasting to embed the footing below the rock surface. E HIGHWAY BRIDGES 747 748 HIGHWAY BRIDGES App. REFERENCES 1. 634 SECTION 19-BRIDGE DECK JOINT SEALS 19.1 19.2 19.3 19.4 19.4.1 19.4.2 GENERAL .... The bearing capacity and settlement of footings on rock is influenced by the presence, orientation and condition of discontinuities, weathering profiles, and other similar features. 459 DESIGN FORCES FOR SEISMIC PERFORMANCE CATEGORY B .... 633 DOCUMENTATION ....633 Working Drawings .... Drilled shaft lateral displacement analysis shall be based on the results of in-situ andlor laboratory testing to characterize the load-deformation behavior of the foundation materials. MSE walls are typically used where conventional gravity, cantilever, or counterforted concrete retaining walls are considered, and are particularly well suited where substantial total and differential settlements are anticipated. 7 Width of Roadway and Sidewalk ....7 STANDARD HIGHWAY CLEARANCES-GENERAL . 10.18.1.2.3 Fillers for welded splices shall conform to the requirements of the ANSVAASHTO/AWS D1.5 Bridge Welding Code. The following in situ tests may be used: --Standard penetration test (SPT), --Cone penetration test (CPT), and -Pressuremeter test. grids and sheets). The effective width is only to be used to calculate the flange bending stress. 516 Drainage Elements .... In addition, as a minimum, high-strength bolted connections for web splices shall be proportioned as eccentrically loaded connections to prevent slip under the most critical combination of shear, moment, and horizontal force due to D + (L + I) at the point of splice. There shall be not less than two fasteners or equivalent weld in each end connection of the angles. Where metallic reinforcements are used in areas of anticipated stray currents within 60 meters (200 feet) of the structure, a corrosion expert should evaluate the potential need for corrosion control requirements. For the case where excavation has advanced down to the first anchor level but the first row of anchors has not yet been installed, the wall shall be treated as a nongravity cantilevered wall and the earth pressure distribution loading on the wall shall be assumed as triangular in accordance with Article 5.6.2. Overstressing of the anchors should be avoided as excessive anchor loads relative to the capacity of the retained ground mass to support the anchor loads can result in undesirable deflections, or passive failure of the wall into the retained soil. 2.7.2.2.4 Design loads for rails located more than 54 inches above the riding surface shall be determined by the designer. For extensible wall systems with a face batter of less than 10" from the vertical, the zone of maximum stress should be determined using the Rankine method. If rock within a depth of 0.5B below the base of the footing is of poorer quality, the RQD of the poorer rock shall be used to determine q,. Numerous research bulletins are noted for references. 347 Service Load Design-safety factor. Friction Pile-A pile whose support capacity is derived principally from soil resistance mobilized along the side of the embedded pile. -- All applications, but with product specific data obtained and analyzed in accordance with FHWA Publication No. FHWA SA-96-071 "Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines"-Appendix B, and FHWA Publication No. FHWA SA-96-072 "CorrosionlDegradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes." Permanent applications not having severe consequences should poor performanceor failure occur, nonaggressivesoils, and polymers meeting the requirements listed in Table 5.8.6.1.2A, provided product specific data is not available. The Interim Specifications of 1997, 1998, 1999,2000,2001,2002 and 2003 have been adopted and are included. The use of a particular in situ test and the interpretationof the results shall take local experience into consideration. These guidelines are for preliminary design of straight shaft anchors installed in small diameter holes using a low grout pressure. lb. In 1997, Section 20, "Disc Bearings,"Division I, was replaced by Section 14, "Bearings." 6. 51 4.4.7.1.1.6 Ground Water .... 83 4.6.5.2.4 GroupAction .... 236 Flanged Sections . 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. - -- - -- - - - 3.30 TIRE CONTACT AREA The tire contact area for the Alternate Military Loading or HS 20-44 shall be assumed as a rectangle with a length in the direction of traffic of 10 inches, and a width of tire of 20 inches. 212 Service Load Stresses ....212 . The presence of cross frames does not ensure that the longitudinal girders are adequately braced. 10.19.2.2 End-connection details shall be designed with special care to provide clearance for making the field connection. .C-17 Figures CONTENTS Figure 14.6.5.2.1 Figure 14.6.5.3.3.1 Figure C14.6.5.3.3.1 Figure C14.6.5.3.6-1 Map of Low Temperature Zones ....396 Load Deflection Behavior of Elastomeric Bearings . .221 . Upto Over2Xin. 357 MATERIALS ....358 Sawn Lumber .... " k i i ml QI L I k t $I I (n I I;; Q L 3 I FIGURE 5.8.5.2A Default Values for the Pullout Friction Factor, P* TABLE 5.8.5.2A Default Values for the Scale Effect Correction Factor, a. strips) use Ton relnforcement ~ n t o r f e c ef r l c t l o n ongle. 659 Nuts and Bolts .... Should the concrete deck be considered effective in tension, for consistency, the resulting stresses due to loads acting on the appropriate composite section are to be combined with the stresses due to loads acting on the noncomposite section to calculate D, for checking web bend-buckling. westereaard. 10.29.1.1 Fixed ends shall be firmly anchored. 3 Structural Integrity .... .76 Cast-in-Place Concrete Piles ....76 Materials ....76 Shape .... C10.40.2.2 Shear This primarily editorial revision is to ensure that the specified minimum yield strength of the web is used to compute the allowable shear stress for a hybrid girder in ASD. Language is added to indicate that if a longitudinal stiffener is used to comply with the web bend-buckling check for constructibility, it must be placed at a location on the web that satisfies Equation (10-173) for constructibility and that also satisfies the strength criteria for the maximum design loads. 335 General .... should be used to determine q,,,. 5.8.6 maintaining allowable material stresses to the end of the 75 or 100 year service life. 540 Water Method .... 67 Bearing .... 471 Flexural Strength . MPa (Table 10.32.1A and Articles 10.37.1.2 and 10.55.1) = stress due to calculated wind load moment, MPa (Article 10.20.2.1) = buckling stress of the compression flange plate or column, MPa (Articles 10.51.1, 10.51.5, 10.54.1.1, and 10.54.2.1) = compressive bending stress permitted about the X axis, MPa (Article 10.36) = compressive bending stress permitted about the Y axis, MPa (Article 10.36) = maximum horizontal force, N (Article 10.20.2.2) = Euler buckling stress, MPa (Articles 10.37.1, 10.54.2.1, and 10.55.1) = Euler stress divided by a factor of safety, MPa (Article 10.36) = computed bearing stress due to design load. The words 'beams and girders' are changed to the word 'sections' throughout this article for consistency. The tension due to prying actions shall be computed as (10 - 168) where Q = prying tension per bolt (taken as zero when negative); T = direct tension per bolt due to external load; a = distance from center of bolt to edge of plate; b = distance from center of bolt to toe of fillet of connected part; t = thickness of thinnest part connected in inches. 342 Seam Strength . "Local Buckling of Fiber-Reinforced Polymeric Structural Members Under Linearly-Varying Edge Loading," Report No. FHWA-RD, May 1995, pp. The wall height is defined as the difference in elevation between the top of the wall at the wall face (i.e., where the finished grade intersects the back of the wall face) and the top of the leveling pad. .206 Approximate Evaluation of Slenderness Effects ....206 Shear . Foundation Requirements for Seismic Performance 469 Category C .... 4.12.3.1.2 Groundwater Table and Buoyancy Ultimate bearing capacity shall be determined using the groundwater level consistent with that used to calculate load effects. C10.50.1.1 Compact Sections The words 'beams and girders' are changed to the word 'sections' in the first sentence of this article for consistency. PRESSURE DISTRIBUTION (2) - 3. flange) = 37.50 ksi Rcu = IFCU~fCUl = (37.50122.751 = 1.65 Rcufnw= (1.65)(-6.75) = -11.I4 ksi Mwu=: 0.5(69m0)~)(1.0)37~50 - (-1 1 .14)(12 =: 9,649 kip-in. Elastomenc Rotational Element . 5.8.1 Structure Dimensions An illustration of the MSE wall element dimensions needed for design is provided in Figure 5.8.1A. No method should be considered capable of predicting settlements of footings on sand with precision. 45 4.4.3 Design Terminology .... 569 Cold Finished Carbon Steel Shafting ....569 Steel Castings .... 541 Bridge Decks .... Precast Concrete Slope Paving . 491 Vibratory Hammers ....492 Additional Equipment or Methods ....492 xlix 1 CONTENTS Division 11 Driving Appurtenances . 449 SITEEFFECTS .... The lateral distribution of the wheel load at the supports shall be that determined by the equation: Wheel Load Fraction per Panel W = 2but not less than 1. .149 Design Life Requirements ....152 Steel Reinforcement .... The foundations of bridges constructed across channels that have been realigned should be designed for possible deepening and widening of the relocated channel due to natural causes. 427 Concrete .... 328 HYBRID GIRDERS .... 312 10.39.6 Lateral Bracing .... Overhanging portions of concrete decks should be provided with a drip bead or notch. On state trunk highways and interstate routes through urban areas, a 16-foot clearance shall be provided except in highly developed areas. These sacrificial thickness requirements are not applicable for soils which do not meet one or more of the nonag- 5.8.6.1 153 DIVISION I-DESIGN A, = bE, E, A, = s t r i p thickness c o r r e c t e d f o r c o r r o s l o n loss. 4.4.5.2 Scour Protection Footings supported on soil or degradable rock strata shall be embedded below the maximum computed scour depth or protected with a scour countermeasure. The number and spacing of the bore holes may be increased or decreased from 30 meters (100 feet), depending upon the anticipated geological conditions within the project area. 400 Elastomeric Disc . AASHTO does not currently give specific requirements for the design of the bracing. 516 Geocomposite Drainage Systems .... Lightweight Concrete .... The details of deck drains should be such as to prevent the discharge of drainage water against any portion of the structure or on moving traffic below, and to prevent erosion at the outlet of the downspout. 4.11.4.2.1 Semi-empirical Procedures 4.11.4.1.5 Effect of Load Eccentricity For loads eccentric to the centroid of the footing, a reduced effective footing area (B' X L') shall be used in design. Since bracing is essentially resisting the tendency of the compression flange to move, it is most effective when attached as close as possible to the flange. 80 4.6.5.1 Axial Capacity in Soil .... LONGITUDINAL BEAMS. 426 REINFORCED CONCRETE BOX, PRECAST ....426 Application .... The net section check based on 0.50f, is eliminated. 194 xxiii CONTENTS Superstructure Depth Limitations .... 382 TENSION MEMBERS .... Primer ....639 Preformed Membrane Sheet ....639 Mastic . 641 Preformed Membrane Waterproofing Systems ....642 General ....642 Installation on Bridge Decks ....642 Installation on Other Surfaces ....642 Protective Cover .... TIMBER RAILING .... Pile-A relatively slender deep foundation unit, wholly or partly embedded in the ground, installed by driving, drilling, augering, jetting, or otherwise, and which derives its capacity from the surrounding soil and/or from the soil or rock strata below its tip. .I41 External Stability for Wall with Broken Backslope ...... 10.7.2 In determining the radius of gyration, r, for the purpose of applying the limitations of the KLlr ratio, the area of any portion of a member may be neglected provided that the strength of the member as calculated without using the area thus neglected and the strength of the member as computed for the entire section with the KLlr ratio applicable thereto, both equal or exceed the computed total force that the member must sustain. 518 Geocomposite Drainage Systems .... To use load factor design procedures for the structural design of driven piles, the load factor design procedures for reinforced concrete, prestressed concrete and steel in Sections 8,9, and 10, respectively, shall be used in place of the allowable stress design procedures. See Section 14 of this specification. 331 Welds .... C10.54.1.2 Effective Length The reference to the existing footnote in this article is revised to accommodate the addition of the new footnote discussed under Article 10.54.1.1. C10.54.2 Combined Axial Load and Bending C10.54.2.2 Equivalent Moment Factar C The current lower limit of 0.4 on the C coefficient contained in the amplification factor for members under combined bending and axial force (in LFD) is eliminated for consistency with the revision to Table 10.36A discussed earlier. 4.8 SCOPE Provisions of this section shall apply for the design of spread footings, driven piles, and drilled shaft foundations. 234 Relaxation of Prestressing Steel .... Permanent nongravity cantilevered walls may be constructed of reinforced concrete, timber, andlor metals. Where a wall is used to support a structure, tolerable movement criteria shall be established in accordance with Articles 4.4.7.2.5.4.5 and 4.6. Where a wall supports soil on which an adjacent structure is founded, the effects of wall movements and associated backfill settlement on the adjacent structure shall be evaluated. 107 4.13.3.2.3b Group Settlement .... 433 Handling and Installation Strength ....433 PLASTIC PIPE ....433 General ....433 Service Load Design-safety factor, SF . 1985). 422 16.4.6.6.2 Shearstinups .... Based on these safety factors, the available connection strength must be greater than Tmd. 459 Design Forces for Structural Members and Connections ....459 Design Forces for Foundations .... 68 General .... .588 . 3.27.3 Open Floors 3.27.3.1 A wheel load shall be distributed, normal to the main elements, over a width equal to 1v4 inches per ton of axle load plus twice the distance center to center of main elements. Number Average Molecular Weight Hydrolysis Resistance Inherent Viscosity Method of 25,000 (ASTM D 4603 and GRI Test Method GG8**) or Determine Directly Using Gel Permeation Chromatography Max. A subsequent article explicitly indicates that the handling requirement need not be applied to longitudinally stiffened girders. 19 LIVELOAD .... The maximum longitudinal fatigue shear range is produced by placing the fatigue live load immediately to the left and to the right of the point under consideration. 318 Design Strength of Connectors .... 491 General .... .550 .... Refer to Article 4.4.7.2.3 for procedures to estimate the consolidation settlement component for shafts extending into cohesive soil deposits. 185 Drainage and Backfilling .... If the compression flange of the girder is smaller than the tension flange, the minimum flange width may be based on two times the depth of the web in compression, D,, rather than the web depth. A note has been added to indicate the removal of this equation to prevent having to renumber d subsequent equations in section 10. Reinforcement for concrete panels shall be provided to resist the average loading conditions for each panel. Several approaches have been used to compute the area of the concrete slab to use in the preceding requirement. the wall dimensrons ore considered t o begrn s t the back of the focing e ements. 510 Testing Equipment .... 268 Diaphragms ....268 Camber ....269 Working Lines and Gravity Axes .... 10.32.3 Load Condition Applied Static TensionbL AASHTO M 164 AASm M 253 (ASM A 325)' (ASTM A 490)' 3gd 47 lgd 24 Shear. The theoretical cutoff point of the cover plate is the section at which the stress in the flange without that cover plate equals the allowable stress, exclusive of fatigue considerations. 10.29.3 Rollers Expansion rollers shall be connected by substantial side bars and shall be guided by gearing or other effectual 286 HIGHWAY BRIDGES means to prevent lateral movement, skewing, and creeping. .673 Placing Culvert Sections .... 2.7.3.2.4 Refer to Figures 2.7.4A and 2.7.4B for more information concerning the application of loads. Where thin drainage panels are used behind walls, saturated or moist soil behind the panels may be subject to Structural design of individual wall elements may be performed by service load or load factor design methods in conformance with Article 3.22. which it bears. (d) Stage-discharge curve for site. PTFE ....392 392 Mating Surface .... 431 Scope .... .59 Elastic Shape and Rigidity Factor, EPRI (1983) ....59 Values of Coefficient N, for Estimation of the Ultimate Bearing Capacity of Footings on Broken or Jointed Rock (Modified after Hoek (1983)) ....63 Typical Range of Uniaxial Compressive Strength (C,) as a Function of Rock Category and Rock Type . When perforations are staggered in opposite cover plates, the cross-sectional area of the member shall be considered the same as for a section having perforations in the same transverse plane. .135 MSE Wall Element Dimensions Needed for Design ...... 500 Casings . 4.13.3.3.2 Analytic Estimates of Drilled Shaji Capacity in Cohesive Soils Analytic (rational) methods may be used to estimate the ultimate bearing capacity of drilled shafts in cohesive soils. 461 Abutments .... 603 Brick .... 504 Test Shafts .... and Elliptical Pipe ....670 Precast Reinforced Concrete Box Sections ....670 ASSEMBLY ....670 General . 35 35 Edge Distance of Wheel Loads ....425 16.6.4.2.2 Trench Installations . 4.11.1.4 Frost Action 4.10.6 Performance Factors Values of performance factors for different types of foundation systems at strength limit states shall be as specified inTables 4.10.6-1,4.10.6-2, and4.10.6-3, unless regionally specific values are available. The words 'beams and girders' are changed to the word 'sections' in the first sentence of this article for consistency. .685 MEASUREMENT . .I14 Terms Used in Design of Rigid Gravity and Semi-Gravity Retaining Walls ....121 Computational Procedures for Active Earth Pressures (Coulomb Analysis) .... 628 Short-term Compression Proof Load Test .... 646 Filter Fabric .... If the soil modulus varies significantly with depth, a weighted average value of E, may be used. 640 . = Undrained shear strength (ksf). 105 4.13.2 Notations .... October 8, 2021May 8, 2021 by Mike Post navigation Normas Aashto t99-t180 Maquinaria y Normas Aashto AASHTO aashto clasificacion AASHTO volume04 AASHTO AASHTO LRFD» AASHTO T88 AASHTO T265 Aashto M145 AASHTO 2002 Intersecciones aashto Compactacion AASHTO AASHTO 1996 AASHTO T224 Skip to main contentNew Standard Spotlight Standard Specifications for Highway Bridges 17th Edition - 2002 Upper right-hand and lower left-hand pictures courtesy of the National Steel Bridge Alliance. (b) Complete data on existing bridges, including dates of construction and performance during past floods. 431 Materials . In metal 3/8 inch thick and over, one-half the depth of countersink shall be omitted in calculating the bearing area. = 4 dlameter o f bar o r wlre c o r r e c t e d f o r c o r r o s l o n loss. 497 SECTION 5-DRILLED PILES AND SHAFTS DESCRIPTION .... Structure Design . As a result, the concrete deck is in compression over a significant portion of the girder length for the fatigue shear loading and the use of the full composite section (including the concrete deck) along the entire span is reasonable. Unless actual data regarding the magnitude of the anticipated surcharge loads is available, assume a minimum soil unit weight of 19.6 kN/m3(0.125 kcf) in determining the surcharge load. Furthermore, these corrosion rates do not apply to other metals. 537 Waterstops ....537 Expansion Joint Armor Assemblies .... 382 Tension Parallel to Grain .... Tension reinforcement at the bottom of the heel shall be provided if required during the construction stage prior to wall backfill. 181 SECTION 7CUBSTRUCTURES PART A . 4.4.7.2.1 Stress Distribution Figure 4.4.7.2.1A may be used to estimate the distribution of vertical stress increase below circular (or square) and long rectangular footings (i.e., where L > 5B). .368 Tabulated Design Values for Bearing Parallel to Grain ....369 Design Values for Structural Glued Laminated Softwood Timber with Members Stressed Primarily in Bending ...370 Design Values for Structural Glued Laminated Softwood Timber with Members Stressed Primarily in Axial Tension or Compression . - : . 329 Composite Hybrid Sections . P, for sloping backfills shall be calculated as follows: 5.8.9.1 External Stability Stability computations (i.e., sliding, overturning, and bearing capacity) shall be made by including, in addition to static forces, the horizontal inertial force (P,) acting simultaneously with 50% of the dynamic horizontal thrust (Pm) to determine the total force applied to the wall. 10.34.3 Thickness of Web Plates 10.34.3.1 Girders Not Stiffened Longitudinally 10.34.3.1.1 The web plate thickness of plate girders without longitudinal stiffeners shall not be less than that determined by the formula t, =- DA (See Figure 10.34.3.1A.) (10-23) 23,000 but in no case shall the thickness be less than Dl170. 314 10.41.2 10.41.3 Effective Width of Deck Plate .... If closer spacing is required, the sequence of construction shall be specified and the interaction effects between adjacent shafts shall be evaluated by the designer. Table C1032.3A Allowable Stresses for Low-Carbon Steel Bolts and Power Driven Rivets Footnote d has been added to indicate that the joint length correction factor

also applies when determining the shear strength of ASTM A 307 bolts (Note: footnotes in all tables in Section 10 have been generally re-ordered in order to place them in a more logical sequence). The additional web strip contributes little to the moment of inertia of the stiffener. .468 .. Overall stability shall be evaluated for footings on or adjacent to sloping ground surfaces as described in Article 4.4.9. S, =1 4.4.7.1.1.3 Inclined Loading 4.4.7.1.1.5 Embedment Depth For inclined loads, the following inclination factors shall be applied in Equation 4.4.7.1.1 -1: i,= i,- [(I - i,)/N, tan 41 (for 4 > 0) (4.4.7.1.1.3-1) The shear strength of soil above the base of footings is neglected in determining quit using Equation 4.4.7.1.1-1. For other footing geometries, refer to Poulos and Davis (1974). 569 Chromium Alloy-Steel Castings .....569 Iron Castings .....569 Materials ..... xlll xiv CONTENTS Moments .....67 . .223 Splices of Welded Smooth Wire Fabric in Tension .....224 SECTION 9-PRESTRESSED CONCRETE PART A . .91 . 184 Collision Walls ..... LENGTH. 107 4.13.3.3.3 Estimation of Drilled-Shaft Capacity in Cohesionless Soils .....107 4.13.3.3.4 Axial Capacity in Rock .....; .....107 4.13.3.3.5 Load Test ..... When these values are used for preliminary design, all load factors shall be taken as unity. 4.12.5 Construction Considerations Foundation design shall not be uncoupled from construction considerations. 10.29.4 Sole Plates and Masonry Plates 10.29.4.1 Sole plates and masonry plates shall have a minimum thickness of Y 4 inch. .625 625 Flat Sheet PTFE ..... SECTION 2 5 C T E E L AND CONCRETE TUNNEL LINERS 25.1 25.2 SCOPE ..... Ultimate Geotechnical Capacity ..... (1974) .....62 Relationship Between Elastic Modulus and Uniaxial Figure 4.4.8.2.2A Compressive Strength for Intact Rock, Modiied after Deere (1968) .....66 Design Terminology for Driven Pie Foundations ..... = number of steel dowels required for the given spans; - R, = (for Douglas fir or Southern pine, use 1,000 psi); total secondary shear transferred, in pounds, determined by the relationship: R,= 6Ps / 1,000 for s 150 inches (3 - 28) or, - R, =(s- 20) for s > 50 inches 2s (3 - 29) My= total secondary moment transferred, in inchpound, determined by the relationship, - Ps M y=(s - 10) for s I 5 0 inches (3 - 30) PS (s - 30) M y=-for s > 50 inches 20 (s - 10) (3- 31) 1,600 R D and M, = shear and moment capacities, respectively, as given in the following table: 3.25.2.2 Normal to the direction of the span the wheel load shall be distributed as follows: Plank floor: 20 inches; Non-interconnected nail laminated floor: width of tire plus thickness of floor, but not to exceed panel width. The weld connecting the cover plate to the flange in its terminal distance shall be continuous and of sufficient size to develop a total stress of not less than the computed stress in the cover plate at its theoretical end. Where footings must be placed on sloping surfaces, refer to Article 4.4.6 for anchorage requirements. Therefore, it is no longer necessary to repeat that statement in this article. 496 MEASUREMENTAND PAYMENT . .472 Spacing of Transverse Reinforcement for Confinement . Dl278 70,000 psi, Y.P. Min. 4.10.5 Load Combinations and Load Factors Foundations shall be proportioned to withstand safely all load combinations stipulated in Article 3.22 which are applicable to the particular site or foundation type. (e) Factors affecting water stages such as high water from other streams, reservoirs, flood control projects, and tides. C10.40.2.1 Bending C10.48 FLEXURAL MEMBERS C10.40.2.1.3 This article is added to indicate that the hybrid factor R is to be taken as 1.0 at sections where the computed bending stresses in both flanges do not exceed the allowable bending stress for the web since web yielding is assumed not to occur in this case. 424 16.6.2 16.6.2.1 Concrete . Suitable metals generally include steel for components such as piles, brackets and plates, lagging and concrete reinforcement. The provisions of Article 4.13 shall apply to the design of drilled shafts, but not drilled piles installed with continuous flight augers that are concreted as the auger is being extracted. SECTION 1 1 C T E E L STRUCTURES GENERAL .....565 Description .....565 Notice of Beginning of Work .....565 Inspection .....565 Inspector's Authority ..... The plates shall be placed to 1.6.2 DIVISION I-DESIGN 5 -- take account of the direction of blast when the locomotive is on level or superelevated tracks by centering them on a line normal to the plane of the two rails at the centerline of the tracks. Steel Railing ..... As a minimum, high-strength bolted connections shall also be proportioned to prevent slip at a force equal to the maximum elastic flexural stress due to D + (L + I) at the midthickness of the flange under consideration for the smaller section at the point of splice times the smaller value of the gross flange area on either side of the splice. 471 Foundation Design ..... 80 4.6.4.2 Measured Values ..... C10.39.4.3 Compression Flange Stiffened Longitudinally C10.39.4.3.7 See C10.39.4.2.6 above. The performance factor for the uplift capacity of the pile group considered as a block shall be as provided in Table 4.10.6-2 for pile groups in clay and in sand. Splices of such members which will be fabricated and erected with close inspection and detailed with milled ends in full contact bearing at the splices may be held in place by means of splice plates and rivets or high-strength bolts proportioned for not less than 50% of the lower allowable design strength of the sections spliced. 50 70 hterior End 2-spa 65 50 60 70 55 70 60 45 60 75 75 85 85 25 30 30 75 85 80 55 65 75 'Continuous beam of 2 equal spans. In the absence of specific data, a maximum friction angle of 30" should be used. whichever i s lowest. Multiple hardened washers with combined thickness equal to or greater than 5/16 inch do not satisfy this requirement. 93 Groundwater . Revisions to this article clarify that only composite sections of constant-depth flexural members without longitudinal web stiffeners and without holes in the tension flange (refer to the commentary to Article 10.18.2.1.5) can qualify as compact sections for positive bending. In all cases, the shaft length shall be determined such that the design structural load can be safely supported entirely below the probable scour depth. 126 Counterforts and Buttresses .....128 Reinforcement ..... 232 Stress at Service Load After Losses Have Occiured .....232 Cracking Stress .....: ..... 10.16.14.4 At a splice, the total stress in the member being spliced is transferred by fasteners to the splice material. 111 111 Rigid Gravity and Semi-Gravity Walls ..... For simple spans, the maximum live load moment per foot width of slab, without impact, is closely approximated by the following formulas: + HS 20 Loading: Spans up to and including 50 feet: LLM = 900s foot-pounds Spans 50 feet to 100 feet: LLM = 1,000 (1.30s-20.0) foot-pounds 3.24.3 HS 15 Loading: Use 3/4 of the values obtained from the formulas for HS 20 Loading Moments in continuous spans shall be determined by suitable analysis using the truck or appropriate lane loading. The word 'unsymmetrical' is replaced with the words 'singly symmetric'. Description ..... In the above, D (depth of the web) is the clear unsupported distance in inches between the flange components, t, is the web thickness, k is the buckling coefficient, d, is the distance from the centerline of a plate longitudinal stiffener or the gage line of an angle longitudinal stiffener to the inner surface or the leg of the fb (ksi) WEB THICKNESS AND GIRDER DEPTH ,(a function of bending stress) D = depth of web tw = thickness of web fb = calculated compressive bending stress in flange FIGURE 10.343.1A Web Thickness vs. .....230 DEFLECTIONS ..... The net section of the part is obtained from the chain that gives the least net width. C10.48.1 Compact Sections Revisions to this article clarify that only sections of properly braced constant-depth flexural members without longitudinal web stiffeners, without holes in the tension flange (refer to the commentary to Article 10.18.2.1.5), and with high resistance to local buckling can qualify as compact sections. For seismic loading, the location of R shall be within B/3 of the center of the foundation for foundations on soil and rock. .307 10.32.1 10.32.2 10.32.3 10.32.3.1 10.32.3.3 10.32.3.4 10.32.4 10.32.5 Division I Division I CONTENTS 10.39.3 Design of Web Plates ..... The language is also revised to indicate that fbin the width-to-thickness ratio requirement is to be taken as the lesser of the calculated bending stress in the compression flange divided by R or the allowable bending stress for the compression flange. (See Division 11.) Determination of the unbonded anchor length shall consider the location of the critical failure surface farthest from the wall, the minimum length required to insure minimal loss of anchor prestress due to long-term ground movements, and the depth to adequate anchoring strata. 611 Posts . .543 .. 316 DESIGN STRESS FOR STRUCTURAL STEEL .....316 MAXIMUMDESIGNLOADS .....317 FLEXURAL MEMBERS .....317 xxxiii xxxiv CONTENTS Compact Sections ..... .157 Soil Reinforcement/Facing Connection Strength Design .....158 Connection Strength for Steel Soil Reinforcements .....158 Connection Strength for Geosynthetic Reinforcements ..... The actual contact pressure distribution (i.e., trapezoidal for the conventional assumption of a rigid 4.4.7.1.1.1 DIVISION I-DESIGN footing and a positive pressure along each footing edge) shall be used for structural design of the footing. 588 REPAIRING DAMAGED GALVANIZED COATINGS .....588 PLACEMENT OF CONCRETE FILLER ..... 427 Crack Control ..... When the thicknessof& k l e s h n that given by the above formula, the web shall be strengthened by diagonal stiffeners or by a reinforcing plate in contact with the web over the connection area. The maximum angular distortion (81s) between adjacent foundations shall be limited to 0.008 for simple span bridges and 0.004 for continuous span bridges. The strength of compression members connected by highstrength bolts or rivets shall be determined using the gross section. The requirements in the above articles are intended to apply only when the girder is in the final condition. Case B-Main Reinforcement Parallel to Traffic .....36 Shear and Bond . 640 Asphalt Membrane Waterproofing .....641 lxvii lxviii CONTENTS General .....641 Installation ..... 3.25.4 Continuous Flooring If the flooring is continuous over more than two spans, the maximum bending moment shall be assumed as being 80% of that obtained for a simple span. s"! f Q 1 7 2 2" Butt JointA 0 DETAIL OF WIDTH TRANSITION L Butt Joint Narrower Plate I Narrower Plate L ~ i d t of h Wider Plate (b) Straight Tapered Transition 4 (a) 2'-0" Radius Transition FIGURE 10.18.5A Splice Details d . Determine the magnitude of active pressure at the dredge line (Pal due to surcl ..ge loads, retained soil a d differential water pressure, using the earth pressure coefficient K,, . 65 Recommended Factor of Safety on Ultimate Geotechnical Capacity Based on Specified Construction Control . piles and shall be replaced by the articles in this section for load factor design of driven piles, unless otherwise stated. 187 PART C-STRENGTH DESIGN METHOD LOAD FACTOR DESIGN 7.6 GENERAL ..... A load equal to one-half the transverse load on a post shall simultaneously be applied longitudinally, divided among not more than four posts in a continuous rail length. TistSEFaffs~anilB-ex .::.I. segmental concrete fecrng blocks) may be desirable t o ~ n c l u d ethe fecing dimenalona end weight In slldlng end overturning celculetrona (1.a.. This article applies to the computation of the maximum bending strength of symmetric and singly symmetric braced noncompact sections. al., 1993), is discussed in Appendix A of FHWA Publication No. FHWA SA-96-071 "Mechanically Stabilized TABLE 5.8.7.2A Default and Minimum Values for the Total Geosynthetic Ultimate Limit State Strength Reduction Factor at the Facing Connection, RF. 489 MANUFACTURE OF PILES .....490 Precast Concrete Piles . (10 - 20) 10.34.2.2.7 At least one cover plate of the top flange shall extend the full length of the girder except when the flange is covered with concrete. In some cases, a spread footing is used at the base of the anchored wall facing in lieu of vertical element embedment to provide vertical support. Guide to Stability Design Criteria for Metal Structures, Fifth Edition, Structural Stability Research Council, Edited by Theodore V. 401 ..... T or Rev 16 D E 16 E Detail base metal attached by fillet welds with a transition radius, R, regardless of the detail length (shear stress on the throat of fillet welds governed by Category F): 16 -With the end welds ground smooth (a) Transition radius r 2 in. Steel Stress Coefficients Total Dowel Lengih Raguind in. 492 Pile Cushion . For riveted or bolted connections,Article 10.32.3 shall govern. 10.16.10.1 Lacing bars of compression members shall be so spaced that the slenderness ratio of the portion of the flange included between the lacing bar connections will be not more than 40 or more than Y3 of the slenderness ratio of the member. .626 . Because simply-supported boundary conditions are assumed in the development of the equations for k, it is conceivable that the computed web bend-buckling capacity for the longitudinally stiffened web may be less than that computed for a web without longitudinal stiffeners where some rotational restraint from the flanges has been assumed. Other factors which can affect settlement (e.g., embankment loading, lateral andlor eccentric loading, and for footings on granular soils, vibration loading from dynamic live loads or earthquake loads) should also be considered, where appropriate. In counterfort walls, there shall be at least one drain for each pocket formed by the counterforts. distance measured from extreme tension fiber to center of the closest bar or wire (mrn). In load factor design, design load refers to nominal loads multiplied by appropriate load factors. SECTION 1643OIL-REINFORCED CONCRETE STRUCTURE INTERACTION SYSTEMS Figure 16.4A Figure 16.4B Figure 16.4C Figure 16.4D Figure 16.4E Figure 16.4F Figure 16.4G Figure 16.4H Figure 16.6A Heger Pressure Distribution and Arching Factors .....413 Standard Embankment Installations .....414 Standard Trench Installations .....414 Trench Beddings, Miscellaneous Shapes . This book, or parts thereof, may not be reproduced in any form without permission of the publishers. SCOPE . 154 .. 107 4.13.3.2.3a Settlement of Single Drilled Shafts ..... Corrosion-resistant coatings should consist of galvanization. 108 4.13.3.3.8 Group Capacity ..... 608 Hardware .....608 608 Galvanizing ..... 197 Flexure ..... *The slab distribution set forth herein is based substantiallv on the "Westergaard" theory. 107 4.13.3.2.4 Lateral Displacement ..... In determining the FS, the effect of passive soil pressure resistance in front of a wall shall only be considered when competent soil or rock exists which will not be removed or eroded during the structure life. .653 . 425 Strength-Reduction Factors ..... 326 Noncompact Sections ..... Stiffeners are required on the web of the second member opposite the compression flange of the first member when A, t, < --t, +5k (10 - 170) and opposite the tension flange o the first member when f tc I SZI + 'I 0s > > ,I7 slvn 3 u w uo!ssaidx3 3 p p ~ aiiypy iajarus.xw uo!ssaidx3 k ~ u r o p n 3sn APP.E HIGHWAY BRIDGES 711 712 HIGHWAY BRIDGES APP.E 714 HIGHWAY BRIDGES APP.E APP.E HIGHWAY BRIDGES 715 716 HIGHWAY BRIDGES APP.E APP-E HIGHWAY BRIDGES HIGHWAY BRIDGES APP. = moment of inertiaof compression flange about the vertical axis in the plane of the web i n 4 I, d = depth of girder, ia J = w) ~Dc 1 where b and t repsent the flange width and thickness of the compression and tension flange, respectively (in-3 + 3 S, = section modulus with respect to compression flange Cm.3 = modulus of elasticity of steel f E = governing radius of gyration r L = actual unbraced length K = effective length factor (see Appendix C.) ES. 10.32.3.1.6 Joints, utilizing high-strength bolts, required to resist shear between their connected parts are designated as either slip-critical (See Article 10.24.1.4) or bearing-type connections. Vertical clearance on all other highways shall be at least 14 feet over the entire roadway width with an allowance for resurfacing. .I66 Distribution of Stress from Concentrated Horizontal Loads .....I67 Superposition of Concentrated Dead Loads for External Stability Evaluation .....,168 Location of Maximum Tensile Force Line in Case of Large Surcharge Slabs (Inextensible Reinforcements) .. Where heavy reinforcement is required, consideration may be given to an inner and outer reinforcing cage. Load Factor Design-capacity modification factor, . 294 10.34.2.1 Welded Girders ..... 294 HIGHWAY BRIDGES 10.32.6 TABLE 10.32.5.1A Allowable Stresses-Cast Steel and Ductile Iron AASHTO Designation ASTM Designation Class or Grade Minimum Yield Point, F, Axial Tension Tension in Extreme Fibers Axial Compression, Short Columns Compression in Extreme Fibers Shear Bearing, Steel Parts in Contact Bearing on Pins not Subject to Rotation Bearing on Pins Subject to Rotation (such as used in rockers and hinges) M 163 A743 CA-15 65,000 24,000 24,000 32,000 32,000 14,000 48,000 43,000 21,500 10.32.6 Bearing on Masonry 10.34 PLATE GIRDERS 10.32.6.1 The allowable unit-bearing stress in pounds per square inch on the following types of masonry shall be: 10.34.1 General Granite . 629 Bearing Horizontal Force Capacity (Fixed or Guided Bearings Only) ..... 76 Metal Thickness ..... Should the load-shedding factor Rb be less than 1.0, the compression-flange stress is theoretically increased. .628 ; CONTENTS lxvi Bearing Friction Test (for sliding surfaces only) . Tashall be determined on a long-term strength per unit of reinforcement width basis and multiplied by the reinforcement coverage ratio R, so that it can be directly compared to T, which is determined on a load per unit of wall width basis (this also applies to T,, and To).For discrete (i.e., not continuous) reinforcements, such as steel strips or bar mats, the strength of the reinforcement is converted to a strength per unit of wall width basis by taking the long-term strength per reinforcement, dividing it by the discrete reinforcement width, b, and multiplying it by the reinforcement coverage ratio, R,, as shown in Figures 5.8.6A and 5.8.6B. 529 Delivery . Factors such as pile driving, pile splicing, and pile inspection shall be done in accordance with the provisions of this specification and Division 11. .67 Footings on Piles or Drilled Shafts . Cover plates over 14 inches wide shall have four lines of fasteners. When parts in contact have different yield points, Fyshall be the smaller value. The theoretical end of the cover plate, when using service load design methods, is the section at which the stress in the flange without that cover plate equals the allowable service load stress, exclusive of fatigue considerations. Shipment and Storage of Stone .....597 Mortar ..... As a result, a compression flange with a larger slenderness (up to the limiting value of 24 specified in Article 10.48.2.1(a)) can be used at more lightly loaded sections. Configuration 184 ABUTMENTS ..... 571 Holes for High-Strength Bolts and Unfinished Bolts .....571 General .....571 Punched Holes .....572 Reamed or Drilled Holes .....572 Accuracy of Holes .....572 Accuracy of Hole Group .....572 Accuracy Before Reaming .....572 Accuracy After Reaming .....: .....572 Numerically Controlled Drilled Field Connections .....572 Holes for Ribbed Bolts, Turned Bolts, or Other Approved Bearing Q p e Bolts .....572 Preparation of Field Connections ..... 471 Column Shear and Transverse Reinforcement .....472 Transverse Reinforcement for Confinement at Plastic Hinges . 635 Compression Seal Joints . 275 A -S a minimum, in the case of the strengfh----design method, web splice plates and their connections shall be proportioned for a design moment, M,, due to the eccentricity of the design shear at the point of splice defined as Mvu= Vwue The diameter of the holes shall be taken as specified in Article 10.16.14.6. For the flanges and their splice plates subject to compression: A, =A, (10 - 4h) 10.18.2.3 Web Splices 10.18.2.3.1 In general, web splice plates and their connections shall be proportioned for shear, a moment due to the eccentricity of the shear at the point of splice, and a portion of the flexural moment that is assumed to be resisted by the web at the point of splice.* Webs shall be spliced symmetrically by plates on each side. 281 General ..... Neg. 680 680 New Decks ..... .: .....648 General .....648 Cast-in-Place Slope Paving ..... .627 . 611 Caps ..... The commentaries from 1996 through 2000 are provided and have been cross-referenced with each other, where appropriate. 507 Grout ..... .70 . 500 CONSTRUCTION . For a flange splice with inner and outer splice plates, the flange design force shall be proportioned to the inner and outer plates and their connections as specified in Article 10.18.1.3. The effective area, 4 , of each splice plate shall be sufficient to ensure that the stress in the splice plate does not exceed the allowable flexural stress under its calculated portion of the design force. The maximum friction angle used for the computation of horizontal force within the reinforced soil mass shall be assumed to be 34", unless the specific project select backfill is tested for frictional strength by triaxial or direct shear testing methods, AASHTO T 234 and T 236, respectively. Preparation of Slopes 646 .. For continuous spans, the span length is defined as the length between points of contraflexure.Box-girder bottom flanges in compression are also susceptible to the effects of shear lag, if not more so than tension flanges. Multiple hardened washers with combined thickness equal to or greater than %6 inch do not satisfy this requirement. 11.5.5.2 Turned Bolts ..... The change in cell class is made to reflect changes in the Slow Crack Resistance (SCR) tests. 390 390 General Design Considerations ..... MPa (Article 9.16) = nominal diameter of prestressing steel, mm (Articles 9.17 and 9.27) = distance from extreme compressive fiber to centroid of the prestressing force, or to centroid of negative moment reinforcing for precast girder bridges made continuous, mm = distance from the extreme compressive fiber to the centroid of the non-prestressed tension reinforcement, mm (Articles 9.7 and 9.17-9.19) = modulus of elasticity of concrete at transfer of prestress, MPa = loss of prestress due to elastic shortening, MPa (Article 9.16) = base of Naperian logarithms (Article 9.16) = average concrete compressive stress at = area = = = = = = = = = = = = the c.g. of the prestressing steel under full dead load, MPa (Article 9.16) average concrete stress at the c.g. of the presaessing steel at time of release, MPa (Article 9.16) compressive strength of concrete at 28 days, MPa (Article 9.15.2.2) compressive strength of concrete at time of initial prestress, MPa (Article 9.15.2.1) average splitting tensile strength of lightweight aggregate concrete, MPa stress due to unfactored dead load, at extreme fiber of section where tensile stress is caused by externally applied loads. C10.50.2 Negative Moment Sections The words 'of Composite Beams and Girders' are considered redundant and are removed from the heading for this article for consistency with the revision to the heading for Article 10.50. 598 . .647 . The discrete vertical elements typically extend deeper into the ground than the facing to provide vertical and lateral support. Application of Paints . 61 4.4.8 Geotechnical Design on Rock ..... Bent Caps . A modificationis made to indicate that only the radius of gyration, r, and not the moment of inertia, I, of the longitudinal stiffener is to be computed including a web strip up to 18t, in width. Provision for expansion of the tower bracing shall be made in the column bearings. Fasteners 7 8 inch in diameter shall not be used in members carrying calculated stress except in 2%-inchlegs of angles and in flanges of sections requiring %-inch fasteners. If local or punching shear failure is possible, the value of q,,, may be estimated using reduced shear strength parameters c* and +* in Equation (4.4.7.1-1) as follows: Effective stress methods of analysis and drained shear strength parameters shall be used to determine bearing capacity factors for drained loading conditions in all soils. The equation for P, was developed assuming a friction angle of 30". ASTM D 4884 will produce a shortterm connection strength equal to T, X C%. 424 16.6.4.2 Modification of Earth Loads for Soil Structure Interaction . 136 Seismic Pressure .....136 Structure Dimensions and External Stability .....136 Structure Design ..... .481 CONSTRUCTION ..... 689 MEASUREMENT . MATERIALS . Clay (where the strength is greater than 0.5 times normal pressure) where +f = liictional angle of sand, SPT = Standard Penetration Test, CPT = Cone Penetration Test. .258 Allowable Fatigue Stress Range .....260 Untitled ..... Axial Capacity on Rock ..... 532 HANDLING AND PLACING CONCRETE .....532 General ..... Refer to Article 4.4.7.2.5 for additional guidance regarding tolerable vertical and hoizontal movement criteria. 11. .C.44 . 679 Aggregate ..... 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. End cross frames or diaphragms shall be proportioned to adequately transmit all the lateral forces to the bearings. Additional Requirements for Abutments for Seismic Performance Category D . Pitch and Gage of Fasteners .....283 Minimum Spacing of Fasteners ..... See also C10.61 (1997). The widths of outstanding legs of angles in compression (except where reinforced by plates) shall not exceed the following: In main members carrying axial stress, 12 times the thickness. 10. 78 4.5.20.5 Splices . All reduction factors shall be based on product specific data. The limitation also applies when determining the coefficient of sliding friction 5.8.2 DIVISION I-DESIGN 139 For externol end rnternsl steblltty colculot~ons, the welght end dlmenstons of the facrng elements ore qjprcolly rgnored. 425 Minimum Reinforcement ..... Stresses Due to Wind Loading When Top Flanges Are Continuously Supported .....279 Flanges ..... 58 4.4.7.2.4 Secondary Settlement ..... 1.3.1.3 1.4 CULVERT LOCATION, LENGTH, AND WATERWAY OPENINGS Culvert location, length, and waterway openings should be in accordance with the AASHTO Guide on the Hydraulic Design of Culverts in Highway Drainage Guide lines. 499 SUBMITTALS . Development of Reinforcement ..... 4.12.3.2 Movement Under Serviceability Limit State 4.12.3.2.1 General For purposes of calculating the settlements of pile groups, loads shall be assumed to act on an equivalent footing located at two-thirds of the depth of embedment of the piles into the layer which provide support as shown in Figure 4.12.3.2.1-1. .I48 Variation of the Coefficient of Lateral Stress Ratio K f i , with Depth in a Mechanically Stabilized Earth Wall ... .267 TRUSSES ..... 296 Girders Not Stiffened Longitudinally ..... Refer to Gifford, et al., (1987) for guidance regarding application of these procedures. 583 11.6.2 Handling and Storing Materials .....583 11.6.3 Bearings and Anchorages .....583 11.6.4 Erection Procedure .....583 11.6.4.1 Conformance to Drawings .....583 11.6.4.2 Erection Stresses .....584 11.6.4.3 Maintaining Alignment and Camber .....584 11.6.5 Field Assembly .....584 . 346 Aluminum Spiral Rib Pipe and Pipe-Arch RequirementsAASHTO M 197 . 534 General ..... 418 16.4.6.6.3 Maximum Flexural Reinforcement Without Stirrups . Reinforced Column . Therefore, if A > 0.45 g, set A, = A. C10.34 PLATE GIRDERS C10.34.2 Flanges C10.34.2.1 Welded Girders The indicated revision to this ASD article specifies recommended minimum flange proportions for fabricated I-shaped girders. For rock masses which have time-dependent settlement characteristics, the procedure in Article 4.4.7.2.3 may be followed to determine the time-dependent component of settlement. 687 MATERIALS ..... Under combined tension and shear, slip resistance is computed according to the provisions of Article 10.57.3.4. Article 10.56.1.3.3 computes the tensile strength of a bolt or rivet under combined tension and shear. 426 Concrete Cover for Reinforcement .....426 Design ..... 474 Construction Joints in Piers and Columns .....474 xlvii xlviii . ;..... .617 ..... .481 Disposal .....482 MEASUREMENT AND PAYMENT .....482 SECTION 3.. Load test results may be extrapolated to adjacent substructures with similar subsurface conditions. :323 COMPOSITE SECTIONS ..... Assumed Pressure Distribution .....352 Standard Structure End Types ..... Tolerable movement criteria for horizontal foundations displacement shall be developed considering the potential effects of combined vertical and horizontal movement. The local buckling capacity of the stiffener can be tied to the required load the stiffener must support by setting the local buckling capacity equal to the vertical tension field load, which yields the new Equation (10-32a). 197 Reinforcement ..... More stringent criteria may be established by the owner. 688 General ..... 4.2.2.1 Bearing Capacity The bearing capacity of foundations may be estimated using procedures described in Articles 4.4,4.5, or 4.6 for service load design and Articles 4.11, 4.12, or 4.13 for strength design, or other generally accepted theories. .75 Precast Concrete Piles . FIELD ASSEMBLY . 689 StructuralBackfill ..... Stone ..... It is also specified that the sum of the noncomposite and composite dead-load shears be used in making this check. 184 Stub Abutment ..... 428 Minimum Reinforcement ..... Hansen, and K. This revision states that the maximum spacing of transverse stiffeners on longitudinally stiffened girders be limited to 1.5 times the web depth rather than 1.5 times the maximum subpanel depth (both for intermediate stiffeners and at end panels). 85 4.6.5.3.3.2 Rock Mass Discontinuities . 569 Cleaning ..... 68 Reinforcement ..... For completeness, reference to Articles 10.50.1.2 (Noncompact Composite Sections in Positive Bending), 10.50.2.2 (Noncompact Composite Sections in Negative Bending), 10.51 (Composite Box Girders), and 10.53 (Hybrid Girders) is added for the computation of the maximum bending strength of longitudinally stiffened girders. 2) Replacing Mvuwith M,, = Vwoe. Barzegar, F. 40 DISTRIBUTION OF WHEEL LOADS ON STEEL GRIDFLOORS .....41 General ..... 1.3.2 Hydraulic Studies Hydraulic studies of bridge sites are a necessary part of the preliminary design of a bridge and reports of such studies should include applicable parts of the following outline: 1.3.2.1 Site Data (a) Maps, stream cross sections, aerial photographs. Competent rock is defined as a rock mass with discontinuities that are tight or open not wider than YEinch. 5.2.2 Wall Capacity When utilities other than highway drainage must be constructed within the reinforced zone if future access to the utilities would require that the reinforcement layers be cut, or if there is potential for material which can cause degradation of the soil reinforcement to leak out of the utilities into the wall backfill. C10.38.5 Shear puting Q and the moment of inertia of steel girder plus the reinforcement (in computing I) between points of deadload contraflexure. 570 Identification of Steels During Fabrication :. 10.24.3.6 When AASHTO M 253 (ASTM A 490) bolts over 1 inch in diameter are to be installed in an oversize or short slotted hole in an outer ply, hardened washers conforming to ASTM F 436 except with 5/16 inch minimum thickness shall be used under both the head and the nut in lieu of standard thickness hardened washers. Franz U.S. ARMY CORPS OF ENGINEERS-DEPT. Loads on right are applied to posts. Language is also added to differentiate the computation of the maximum strength for compact and noncompact C-134 HIGHWAY BRIDGES composite hybrid sections in both positive and negative bending. There is no Table 10.32.4.2A in the specification. Flexibility Factor . 379 Allowable Stress ..... where, T, / I--- u Inex tensible Rernf orcements Extensrble Relnf orcements S - L .I = The length of reinforcementin the resistant zone of the iYh layer. 653 Anchor Bolts or Studs .....653 PROPORTIONING AND MIXING . 428 .....428 Deflection Control ..... .673 Figures Tables CONTENTS Embankment Beddings, Miscellaneous Shapes . .458 SECTION &DESIGN REQUIREMENTS FOR BRIDGES IN SEISMIC PERFORMANCE CATEGORY B GENERAL ..... For all wall systems, the zone of maximum stress shall be assumed to begin at the back of the facing elements at the toe of the wall. .26 Sidewalk Loading ..... 10.21.4 Where beams or girders comprise the main members of through spans, such members shall be stiffened against lateral deformation by means of gusset plates or knee braces with solid webs which shall be connected to the stiffeners on the main members and the floor beams. , . bFordesign purposes only. 598 Size ..... Refer to Article 1.3.2 and FHWA (1991) for general guidance regarding hydraulic studies and design. (Article 4.6.5.1.2) effective soil unit weight in the ith interval, MN/m3 (Article 4.6.5.1.2) ith increment of shaft length, m factor to account for reduced individual capacity of closely spaced shafts in group. T or Rev B 21 Base metal at net section of riveted connections. distance from extreme compression fiber to centroid of compression reinforcement, mm. The Committee expresses its sincere appreciation of the work of these men and of those active members of the past, whose names, because of retirement, are no longer on the roll. Sufficient clearance shall be provided between the ground surface and underside of caps or beams connecting shafts to preclude the application of uplift loads at the shaftlcap connection due to swelling ground conditions. Div 11. The first sentence under item (2) in this article is eliminated since the above revision to Article 10.48.6.3(a) Existing Equation (10-146) is revised to correspond with the revised Equation (10-98) in Article 10.48.2. A new Equation (10-146a) is also added to this article, which represents the new Equation (10-99) in Article 10.48.2 with the hybrid factor R added. .74 Protection Against Corrosion and Abrasion .....74 Wave Equation Analysis .....74 Dynamic Monitoring .....74 Maximum Allowable Driving Stresses . 10.12 FLEXURAL MEMBERS Flexural members shall be designed using the elastic section modulus except when utilizing compact sections 10.13.4 Any partial length welded cover plate shall extend beyond the theoretical end by the terminal distance, and it shall extend to a section where the stress range in the beam flange is equal to the allowable fatigue stress range for base metal adjacent to or connected by fillet welds. For this approach, the load in the reinforcements is obtained by multiplying a lateral earth pressure coefficient by the vertical pressure at the reinforcement, and applying the resulting lateral pressure to the tributary area for the reinforcement. .83 4.6.5.2.2 Groundwater . The layering and compaction of the fill material should be systematic everywhere, with the same thickness of layer and number of passes with the compaction equipment used as for the inspected fill. Split Ring Connectors .....608 Shear-Plate Connectors . 5.2.1.4 Mechanically Stabilized Earth Walls MSE systems, whose elements may be proprietary, employ either metallic (strip or grid type) or geosynthetic (geotextile, strip, or geogrid) tensile reinforcements in the soil mass, and a facing element which is vertical or near vertical. Earth Pressure Due to Surcharge ..... 598 Shape ..... 657 lxix CONTENTS lxx MATERIALS AND FABRICATION ..... 4.6.7 Load Testing 4.6.7.1 General Where necessary, a full scale load test (or tests) should be conducted on a drilled shaft foundation(s) to confirm response to load. Ku=the absolute value of the ratio of F,, to fcufor the controlling flange fncu=flexural stress due to the factored loads at the mid-thickness of the noncontrolling flange at the point of splice concurrent with fcu(positive for tension; negative for compression) 10.18.2.3.5 As a minimum, in the case of the strength design method, web splice plates and their connections shall be proportioned to develop the most critical combi- 276 HIGHWAY BRIDGES nation of V, M,, M, and H., The connections shall be proportioned as eccentrically loaded connections to develop the resultant design force through shear in the bolts and bearing at the bolt holes, as specified in Article 10.56.1.3.2. In addition, as a minimum, high-strength bolted connections for web splices shall be proportioned as eccentrically loaded connections to prevent slip under the most critical combination of: 1) an overload design shear, V,,, 2) an overload design moment, Mvo,due to the eccentricity of the overload design shear, 3) an overload design moment, M,,, applied at mid-depth of the web representing the portion of the flexural moment that is assumed to be resisted by the web, and 4) for sections where the neutral axis is not located at the mid-depth of the web, an overload horizontal design force resultant, H,,, applied at mid-depth of the web, as follows: (10 - 4n) VWO = VO where: + V, = maximum shear in the web due to D PL(L+I) at the point of the splice, where P, is defined in Article 3.22 (10 - 40) Mvo = Vwoe 10.18.2.3.6 As a minimum, in the case of the service load design method, web splice plates and their connections shall be proportioned for a design shear stress in the web at the point of splice, F,, defined as follows: For fvc 0.5Fv: For f, 2 0.5Fv: where: fv = maximum shear stress in the web at the point of splice Fv= allowable shear stress in the web at the point of splice 10.18.2.3.7 As a minimum, in the case of the service load design method, web splice plates and their connections shall be proportioned for a design moment, Mv,due to the eccentricity of the design shear at the point of splice defined as follows: M,, and H,, may be computed as follows: MV= FwDtwe M wo ="-t D~ If0 - fof I (10 - 4 ~) t D Hwo=L(fo+f 2 (10 - 4 4 12 of) where: f, + maximum flexural stress due to D PL(L+I)at the mid-thickness of the flange under consideration for the smaller section at the point of splice (positive for tension; negative for compression) fof= flexural stress due to D PL(L+I) at the midthickness of the other flange at the point of splice concurrent with f, in the flange under consideration (positive for tension; negative for compression) = 10.18.2.3.5 + f, and fofshall be computed using the gross section of the member. Tan p if continuous or near continuous reinforcement layers are used, where p is the soillreinforcement interface angle for the bottom of the lowest reinforcement layer. 544 Epoxy Bonding Agents for Precast Segmental Box Girders . 36 Truck Loads ..... 4.11.4.1.4 Presumptive Values Presumptive values for allowable bearing pressures on soil and rock, given in Table 4.11.4.1.4- 1, shall be used only for guidance, preliminary design or design of temporary structures. 318 Transitions . 4.11.4.1.3 Plate Loading Test Bearing capacity may be determined by load tests providing that adequate subsurface explorations have been made to determine the soil profile below the foundation. 4.11.3.4.1 Settlement of Footings on Cohesionless Soils Estimates of settlement of cohesionless soils shall make allowance for the fact that settlements in these soils can be highly erratic. 236 xxviii CONTENTS FLEXURAL STRENGTH .....236 General ..... Concrete Box Sections ..... Public Roads, March 1930,"Computation of Stresses in Bridge Slabs Due to Wheel Loads," bv H. 4.6.6.3 Enlarged - Bases Enlarged bases shall be designed to insure that plain concrete is not overstressed. For retaining structure applications designated as having severe consequences should poor performance or failure occur, a 100-year service life shall be considered. .563 . 3.24.5 Cantilever Slabs 3.24.5.1 Truck Loads Under the following formulas for distribution of loads on cantilever slabs, the slab is designed to support the load independently of the effects of any edge support along the end of the cantilever. 10.21.6 Bracing shall be composed of angles, other shapes, or welded sections. Based on the revisions discussed above, this article is no longer necessary and is removed. The stiffness factor EI of the stiffenershall not be less than 80,000 kip-in2. 105 4.12.4 Structural Design ..... Bolts shall be not less than 5/8 inch in diameter. For seismic design, seismic loads may be reduced, as result of lateral wall movement due to sliding, for what is calculated based on Division 1A using the MononobeOkabe method if both of the following conditions are met: the wall system and any structures supported by the wall can tolerate lateral movement resulting from sliding of the structure, the wall base is unrestrained regarding its ability to slide, other than soil friction along its base and minimal soil passive resistance. 10.19.1 General 10.19.1.1 Except as otherwise provided herein, connections for main members shall be designed in the case of service load design for a capacity based on not less than the average of the calculated design stress in the member at the point of connection and the allowable stress of the member at the same point, but, in any event, not less than 75% of the allowable stress in the member. Maximum moments, shears, and reactions are given in tables, Appendix A, for H 15, H 20, HS 15, and HS 20 loadings

elements are partially embedded in the soil/rock to provide fixity. Therefore, where the load is maximum, Ta shall be determined in accordance with Article 5.8.6.2.1 for steel reinforcement and Article 5.8.6.2.2 for geosynthetic reinforcement. Ties for Horizontal Shear . Drilled shafts may be constructed using the dry, casing or wet method of construction,or a combination of methods. Surface Testing and Correction ..... E HIGHWAY BRIDGES 731 732 HIGHWAY BRIDGES APP.E HIGHWAY BRIDGES 733 734 HIGHWAY BRIDGES APP.E HIGHWAY BRIDGES 735 736 HIGHWAY BRZDGES APP. Finally, an editorial revision is made to insert the lower limits for the bend-buckling coefficient for longitudinally stiffened girders (see earlier discussion on the revisions to ASD Article 10.34.3.2.1). .C.47 . 689 Installation Deflection ..... Local web bend-buckling is explicitly checked for the constructibility load case according to Equation (10-173). 5.2 WALL TYPE AND BEHAVIOR Retaining walls are generally classified as gravity, semigravity, non-gravity cantilever, and anchored. 176 Water Pressure and Drainage .....176 Seismic Pressure ..... Determine the active earth pressure on the wall due to surcharge loads, the retained soil and differential water pressure above the dredge line (refer to Table 5.6.2A for determination of Ka I. The tolerable movement criteria shall be established by empirical procedures or structural analyses. 654 Weather Limitations ..... 231 Design Theory and General Considerations ..... For a noncompact composite section (where stresses must not exceed the yield stress), dead- and live-load moments are applied to different sections. Where vertical displacements are small, horizontal displacements should be limited to 1% inch or less (Moulton, et al. 339 Loads ..... 505 Drilled Shaft ..... The total value of S, is the summation of S, for each increment. 571 Abutting Joints ..... 179 Expansion and Contraction Joints ..... 290 HIGHWAY BRIDGES TABLE 10323A Allowable Stresses for Low-Carbon Steel Bolts and Power Driven Rivets (in psi) 'Qpe of Fastener Tensiona (A) Low-Carbon Steel 18,000 BoltsC 'nulled Bolts (ASTM A 307) Ribbed Bolts (B)Power-Driven Rivets (rivets driven by pneumatically or electrically operated hammers are coosidered powe driven) Structural Steel Rivet Grade 1 (ASTM A 502 Grade 1) Structural Steel Rivet (high-strength) Grade 2 (ASTM A 502 Grade 2) Shear Bearing-'Qpe 13earingb Connectiona 20,000 1 1,000* 40.000 13,500 40,000 20,000 10.32.3.1.4 In bearing-type connections, pull-out shear in a plate should be investigated between the end of the plate and the end row of fasteners. 649 Division 11 Division II CONTENTS 22.5.2 22.5.2.1 22.5.2.2 22.5.2.3 22.5.2.4 22.5.2.5 22.5.2.6 22.5.2.7 22.5.2.8 22.5.2.9 Cast-in-Place Concrete Slope Paving .....650 Precast Concrete Slope Paving .....650 Filter Fabric ..... 594 PAINTING GALVANIZED SURFACES .....594 PAINTING TIMBER .....595 General .....595 Preparation of Surfaces .....595 595 Paint ..... Representative Tabulated Design Values for Parallel Strand Lumber, Design Values in Pounds Per Square Inch (psi) ...376 Load Duration Factor, CD ..... 98 HIGHWAY BRIDGES 4.11.4.1.1 Theoretical Estimation The bearing capacity should be estimated using accepted soil mechanics theories based on measured soil parameters. MEASUREMENT AND PAYMENT ..... 618 Special Material Requirements for PTFE Sliding Surfaces .....619 18.4.3 18.4.3.1 PTFE .....619 18.4.3.2 Adhesives . 4.13.3.3.6~ Uplift Capacity of a Single Drilled Shaft The uplift capacity of a single straight-sided drilled shaft shall be estimated in a manner similar to that for estimating the ultimate side resistance for drilled shafts in compression (Articles 4.13.3.3.2, 4.13.3.3.3, and 4.13.3.3.4). Safety factors less than 0.55, such as the 0.48 factor applied to grid members, account for the greater potential for local overstress due to load nonuniformities for steel grids than for steel strips or bars. 2.2.4 Other The channel openings and clearances shall be acceptable to agencies having jurisdiction over such matters. 603 MATERIALS ..... General .....280 Effective Size of Fillet Welds .....280 Maximum Size of Fillet Welds .....280 Minimum Size of Fillet Welds .....280 Minimum Effective Length of Fillet Welds . 342 BucMing ..... 4.6.5.3.3.3 Method of Construction The effect of the method of construction on the engineering properties of the rock and the contact between the rock and shaft shall be considered as a part of the design process. C10.48.6 Longitudinally Stiffened Girders The existing language in this article refers to the requirements for symmetrical girders only. Steels that are manufactured to a specified minimum yield point greater than 50,000 psi, except for Grade HPS70W steel, shall not be heat-curved. In seismically active areas, consideration shall be given to the potential settlement of footings on sand resulting from ground motions induced by earthquake loadings. 490 Cast-in-Place Concrete Piles . 535 Forms at Construction Joints ..... C10.57 OVERLOAD A new paragraph is added to clanfy the definition of overload when consideringAASHTO Group I, Group IA, or Group I1 load combinations. .626 Fabric Reinforced Elastomeric Pads . 10.34.2.1.2 When cover plates are used, they shall be designed in accordance with Article 10.13. MEASUREMENT AND PAYMENT ..... 316 ASSUMPTIONS ..... The lateral displacement of a pile foundation shall not exceed the tolerable lateral displacement, as selected according to Article 4.12.3.2.2. The lateral displacement of pile groups shall be estimated using procedures that consider soil-structure interaction. Gemeny, R. 662 . .4 ROADWAYDRAINAGE .....4 RAILROAD OVERPASSES . 10.24.1.1 In proportioning fasteners, for shear and tension the cross-sectional area based upon the nominal diameter shall be used. 380 Eccentric Loading or Combined Stresses .....381 Compression ..... If the size of the pedestal permits, the webs shall be rigidly connected transversely.The minimum thickness of the metal in cast steel pedestals shall be 1 inch. 3.24.10 Distribution Reinforcement 3.24.10.1 To provide for the lateral distribution of the concentrated live loads, reinforcement shall be placed transverse to the main steel reinforcement in the bottoms of all slabs except culvert or bridge slabs where the depth of fill over the slab exceeds 2 feet. .418 16.4.6.6.3.1 Limited by Radial Tension .....418 16.4.6.6.3.2 Limited by Concrete Compression .....418 16.4.6.6.4 Crack Width Control (Service Load Design) .....418 16.4.6.6.5 Shear Strength ..... The maximum size that may be used along edges of connected parts shall be: (1) Along edges of material less than Y4 inch thick, the maximum size may be equal to the thickness of the material. 194 Superstructure Deflection Limitations ..... 10.24.1.6 Bolted bearing-type connections using high-strength bolts shall be limited to members in compression and secondary members. In determining the depth of embedment to mobilize passive resistance, consideration shall be given to planes of weakness (e.g., slickensides, bedding planes, and joint sets) that could reduce the strength of the soil or rock determined by field or laboratory tests. For Control of Mix Design ..... 10.27.2.2 Intersecting diagonal bars not far enough apart to clear each other at all times shall be clamped together at the intersection. DEFINITIONS ..... 608 SECTION IS-BEARINGS Table 18.4.3.1.1 Table 18.4.5.1.1 A Table 18.4.5.1-lB Table 18.4.7.1.1 Table 18.5.1.5-1 Physical Properties of PTFE .....619 Material Tests-polychloroprene .....621 Material Tests-plyisoprene .....622 Physical Properties of Polyether Urethane .....623 Fabrication Tolerances and Surface Finish Requirements . 257 Cast Steel. .544 Test 4--The e-Point Tensile Bending Test .....545 Test 54ompression Strength of Cured Epoxy Bonding Agent ..... 3.29 MOMENTS, SHEARS, AND REACTIONS 3.27.3.2 The strength of the section shall be determined by the moment of inertia method. 562 General ..... The bearing capacity and settlement of vertical wall elements under the vertical component of the anchor forces and other vertical loads shall be determined in accordance with Articles 4.4,4.5, or 4.6. For walls supported in or through soft clays with S, < 0.3yrH, continuous vertical elements extending well below the exposed base of the wall may be required to prevent heave in front of the wall. 171 Bearing Capacity and Foundation Stability .....173 Allowable Stresses .....174 Drainage ..... 601 Concrete ..... 64 4.4.10 DynamidSeismic Design ..... A suitable procedure may be based on the elastic properties of the materials as follows: E, = 1 for slab in which the net concrete thickness is less than half the overall depth of the composite section Ec = 2 for slab in which the net concrete thickness is E, at least half the overall depth of the composite section E, - = 18.75 (for Douglas fir and Southern pine) L in which, E, = modulus of elasticity of concrete; E, = modulus of elasticity of wood; E, = modulus of elasticity of steel. For members with eccentric loading, see Article 10.36. 285 . 679 Materials . 682 Construction Joints ..... This article specifies the LFD requirement for minimum longitudinal reinforcement in the concrete deck. 25 REDUCTION IN LOAD INTENSITY ..... Cross-Section Adjustment for Corrosion . .I22 Ultimate Friction Factors and Friction Angles for Dissimilar Materials, after U.S. Department of the Navy (1982) .....I28 General Notes and Legend Simplified Earth Pressure Distributions for Permanent and Temporary Flexible Cantilevered Walls with Discrete Vertical Wall Elements . .631 Test Requirements for Bronze and Copper Alloy Bearings .....631 Test Requirements for Disc Bearings .....632 Material Certification Tests .....632 Testing by the Engineer .....632 Bearing Tests ..... ; .....398 Elastomeric Pads and Steel Reinforced Elastomeric BearingsMethodA .....398 General .....398 Material Properties .....398 Design Requirements .....398 Scope .....398 Compressive Stress .....399 Compressive Deflection ..... 107 4.13.3.1.2 Uplift ..... 4.4.8.2.2 Footings on Broken or Jointed Rock Where the criteria for competent rock are not met, the influenceof rock type, condition of discontinuities and degree of weathering shall be considered in the settlement analysis. In these cases Fyof the compression flange is to be used in calculating the web slenderness requirement. 435 Ribbed PE pipe requirements ..... GROUND S U R F A C E 7 FIGURE 4.4.7.1.1.88 Definition Sketch for Footing Base Inclination 58 HIGHWAY BRIDGES 4.4.7.2.2 Elastic Settlement The elastic settlement of footings on cohesionless soils and stiff cohesive soils may be estimated using the following: Refer to Table 4.4.7.2.2Afor approximate values of E, and v for various soil types, and Table 4.4.7.2.2B for values of p, for various shapes of flexible and rigid footings. Requests for such permits from the U.S. Coast Guard should be addressed to the appropriate District Commander. Miscellaneous Shapes .....417 Suggested Design Pressure Distribution Around a Buried Concrete Pipe for Analysis by Direct Design .....420 Essential Features of Types of Installation .....420 General Relationship of Vertical Earth Load 421 and Lateral Pressure ..... Combination End-Bearing and Friction Pile-Pile that derives its capacity from the contributions of both end bearing developed at the pile tip and resistance mobilized along the embedded shaft. Dl165 50,000 psi, Y.P. Min. Because yielding on the gross section and fracture on the net section are to be explicitly checked, the former footnote d referring to the use of the 15% rule for the gross section check is redundant and is eliminated here. They generally cannot be used effectively where deep soft soils are present, as these walls depend on the passive resistance of the soil in front of the wall. They are calculated for the standard truck or the lane loading applied to a single lane on freely supported spans. 72 Uplift Loads on Piles ..... 196 ConcreteArches . 37 Longitudinal Edge Beams .....37 Unsupported Transverse Edges .....37 Distribution Reinforcement ..... 2.7.1. I.1 Although the primary purpose of traffic railing is to contain the average vehicle using the structure, consideration should also be given to (a) protection of the occupants of a vehicle in collision with the railing, (b) protection of other vehicles near the collision, (c) protection of vehicles or pedestrians on roadways underneath the structure, and (d) appearance and freedom of view from passing vehicles. Thus, the minimum longitudinal reinforcement (including the londtudinal distdbution reinforcement) cOm~utedusing the full deck area should be distributed across the entire deck and not just within the effective width. Greater depths may be required where warranted by local conditions. The type transition selected shall be consistent with the Fatigue Stress Category from Table 10.3.1B for the Groove Welded Connection used in the design of the member. Water Pressure and Drainage ..... 527 Approval ..... 205 Slenderness Effects in Compression Members ..... 277 277 Tension Members ..... 542 Class &Tooled F i s h ..... The current reference in this article to Article 10.48.8.1 is changed to the more correct reference to Article 10.48.8, which parallels a similar reference given in Article 10.48.5.3. The indicated revision to this article clarifies that the width-to-thickness ratio for a longitudinal stiffener is to be checked using the yield strength of the longitudinal stiffener in Equation (10-105). For most applications, permanent retaining walls should be designed for a minimum service life of 75 years. 10.7.5 For tension members, except rods, eyebars, cables, and plates, the ratio of unbraced length to radius of gyration shall not exceed 200 for main members, shall not exceed 240 for bracing members, and shall not exceed 140 for main members subject to a reversal of stress. -11 PedestrianRailing .....12 General .....12 Geometry and Loads . 5.2.23 Overall Stability The overall stability of slopes in the vicinity of walls shall be considered as part of the design of retaining walls. .521 . 11.5.6 Connections Using High-Strength Bolts . Flush median slabs shall be designed without overstress. Table 10.57Aprovides slip resistances for bolts. Capacity may be verified with pile load test results, use of wave equation analysis, use of the dynamic pile analyzer or, less preferably, use of dynamic formulas. (c) Effect of natural geomorphic stream pattern changes on the proposed structure. 569 Steel Forgings ..... 2.7.1.2.3 The lower element of a traffic or combination railing should consist of either a parapet projecting at least 18 inches above the reference surface or a rail centered between 15 and 20 inches above the reference surface. If geosynthetic facing elements must be left exposed permanently to sunlight, the geosynthetic shall be stabilized to be resistant to ultraviolet radiation. For footings on competent rock, reliance on simple and direct analyses based on uniaxial compressive rock strengths and RQD may be applicable. For this case, the shear strength of the connection shall be checked for the maximum calculated splice plate force acting on a single shear plane. 83 4.6.5.2.4.1 Cohesive Soil ..... 90 Longitudinal Bar Spacing .

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