

(5) *Structural response to earthquake loads.* (i) Platforms located in seismically active areas shall be designed to possess adequate strength and stiffness to withstand the effects of an earthquake which has a reasonable likelihood of not being exceeded during the lifetime of the structure (see paragraph (c)(2)(iii) of this section) and remain stable during rare motions of greater severity;

(ii) The adequacy of structural strength shall be demonstrated by analysis to verify that no significant structural damage occurs; and

(iii) Platforms shall also possess adequate ductility to withstand a rare intense earthquake.

(6) *Fatigue assessment.* (i) Structural members and joints for which fatigue is a probable mode of failure and for which past experiences are insufficient to ensure safety from possible cumulative fatigue damage shall be analyzed. Emphasis shall be given to joints and members in the splash zone, those that are difficult to inspect and repair after the platform is in service, and those susceptible to corrosion-accelerated fatigue, and

(ii) For structural members and joints which require a detailed analysis of cumulative fatigue damage, the results of the analysis shall indicate a minimum calculated life of twice the design life (see § 250.906(c)(1) of this part) of the platform if there is sufficient structural redundancy to prevent catastrophic failure of the platform as a result of fatigue failure of the member or joint under consideration. If such redundancy does not exist or if the desirable degree of redundancy is significantly reduced as a result of fatigue damages, the results of a fatigue analysis shall indicate a minimum calculated life of three times the design life of the platform.

(d) *Corrosion protection.* All materials shall be protected from the effects of corrosion by a corrosion-protection system. The design of such systems shall take into account the possible existence of stress corrosion, corrosion fatigue, and galvanic corrosion. If the intended sea environment contains unusual contaminants, any special corrosive effects of such contaminants shall also be considered. Protection systems

shall be designed in accordance with the National Association of Corrosion Engineers (NACE) publication, NACE Standard RP-01-76, Recommended Practice, Corrosion Control of Steel, Fixed Offshore Platforms Associated With Petroleum Production, or other comparable standards.

(e) *Connection of piles to structure.* The attachment of the jacket structure to the piles shall be accomplished by positive, controlled means. Such attachments shall be capable of withstanding the static and long-term cyclic loadings to which they will be subjected.

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§ 250.908 Concrete-gravity platforms.

(a) *General.* (1) This section covers the materials, analysis, design, and construction of reinforced and/or prestressed concrete-gravity platforms.

(2) Materials, structural systems, methods of design, and methods of construction that do not conform to the requirements of this section shall not be used unless it is shown that they will result in a safety level at least equivalent to that provided by the direct application of the requirements of this section.

(b) *Materials—(1) General.* All materials shall be selected with due attention to their strength and durability in the marine environment. All material tests shall be performed in accordance with the latest, applicable standards of the American Society for Testing and Materials (ASTM).

(2) *Cement.* (i) Cement must be equivalent to Type I, II, or III portland cement as specified by ASTM Standard C 150-99, Standard Specification for Portland Cement, or portland-pozzolan cement as specified by ASTM Standard C 595-98, Standard Specification for Blended Hydraulic Cements. However, the suitability of Type III cement to serve its intended function must be demonstrated.

(ii) The tricalcium aluminate content of the cement shall be such as to enhance the corrosion protection of reinforcing steel without impairing the durability of concrete.

(iii) If oil storage is planned and the oil is expected to contain soluble sulfates in amounts that may impair the durability of concrete, the tricalcium content shall be reduced or a suitable coating employed to protect the concrete.

(3) *Water.* (i) Water used in mixing concrete shall be clean and free from injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances that may be deleterious to concrete or steel.

(ii) If nonpotable water is used, the proportions of materials in the concrete shall be based on test concrete mixes using water from the same source. The strength of mortar test cubes made with nonpotable water shall not be significantly below the strength of similar cubes made with potable water.

(iii) Water for reinforced or prestressed concrete or grout shall not contain chlorides and sulfates in amounts detrimental to the durability of the platform.

(4) *Aggregates.* (i) Aggregates must conform to the requirements of ASTM Standard C 33-99a, Standard Specification for Concrete Aggregates. Lightweight aggregates conforming to ASTM Standard C 330-99, Standard Specification for Lightweight Aggregates for Structural Concrete, will only be permitted if they do not pose durability problems and where they are used according to the applicable provisions of the ACI publication, ACI Standard 318, Building Code Requirements for Reinforced Concrete, plus Commentary.

(ii) Marine aggregates shall be washed with fresh water before use to remove the surface and soluble chlorides and sulfates so that the total chloride and sulfate content of the concrete mix water does not exceed the limits of paragraph (b)(3)(iii) of this section.

(iii) The maximum size of the aggregate shall be such that the concrete can be placed without voids.

(5) *Admixtures.* The admixture shall be shown capable of maintaining essentially the same composition and performance throughout the work as the product used in establishing concrete proportions. Admixtures containing

chloride ions shall not be used in prestressed concrete or in concrete containing aluminum embedments.

(6) *Reinforcing and prestressing systems.* (i) Reinforcing and prestressing systems shall conform to the requirements of ACI 318; and

(ii) Structural steel used in composite structures shall conform to the requirements of § 250.907 of this part.

(7) *Concrete.* The concrete shall be designed to ensure sufficient strength and durability. The quality control of concrete shall conform to ACI 318. The mixing, placing, and curing of concrete shall conform to the requirements of paragraph (e) of this section. The water-cement ratio shall be strictly controlled and in no case shall it exceed 0.45.

(8) *Grout for bonded tendons.* (i) Grout for bonded tendons shall conform to ACI 318; and

(ii) The maximum allowable contents of chlorides and sulfates determined in accordance with paragraph (b)(3)(iii) of this section shall also apply to grout mixes.

(9) *Post-tensioning ducts.* Post-tensioning ducts shall conform to the requirements of ACI 318. Ducts and duct splices shall be watertight and grout-tight and shall be of suitable thickness to prevent crushing, deformation, and blockage.

(10) *Post-tensioning anchorages and couplers.* Post-tensioning anchorages and couplers shall conform to the requirements of ACI 318.

(c) *Design requirements—(1) General.* (i) The strength of the platform shall be adequate to resist failure of the platform or its components. Among the modes of possible failure that shall be considered are the following:

- (A) Loss of overall equilibrium,
- (B) Failure of critical sections, and
- (C) Instability (buckling).

(ii) Additionally, the following items shall be considered in relation to their potential influences on the platform:

- (A) Cracking or spalling,
- (B) Deformations,
- (C) Corrosion of reinforcement or deterioration of concrete, and
- (D) Vibrations.

(2) *Required strength.* The required strength shall conform to requirements of ACI 357R.

(3) *Design strength.* The design strength shall conform to requirements of ACI 318 and ACI 357R.

(4) *Other design requirements.* (i) In considering those items listed in paragraph (c)(1)(ii) of this section, the ability of the platform to withstand unfactored loads in the following combination shall be demonstrated:

$$D+T+L+E_0$$

where L represents the most unfavorable live load; D, the dead load; T, the deformation load; and E_0 , the operating environmental load, and

(ii) Crack control design shall be achieved by limiting the crack width in concrete subjected to tension or by limiting the tensile stress in reinforcing steel and prestressing tendons.

(5) *Durability.* (i) Materials, design, construction procedures, and quality control shall be such as to produce satisfactory durability of platforms in a marine environment, and

(ii) The following items shall be considered in the four zones of exposure (see § 250.906(c)(5) of this part):

(A) Submerged zone—chemical deterioration of the concrete, corrosion of the reinforcement and hardware, and abrasion of the concrete;

(B) Splash zone—freeze-thaw durability, corrosion of the reinforcement and hardware, the chemical deterioration of the concrete, and fire hazards;

(C) Atmospheric zone—freeze-thaw durability, corrosion of reinforcement and hardware, and fire hazards; and

(D) Ice zone—mechanical deterioration resulting from the abrasive action of moving ice.

(6) *Fatigue.* Platforms for which fatigue is a probable mode of failure shall be designed to limit the effects of cumulative material fatigue. The effects of fatigue induced by normal stress and those resulting from shear and bond stress shall be considered. Particular attention shall be given to submerged areas subjected to the low-cycle, high-stress components of the anticipated loading history. If an analysis of the fatigue life is performed in lieu of employing other methods to obviate the possibility of fatigue damage, the calculated fatigue life of the platform shall be at least twice the design life (see § 250.906(c)(1) of this part).

(d) *Analysis and design—(1) General.* (i) The analysis of platforms shall be pursued under the assumptions of linearly elastic materials and linearly elastic structural behavior, except as listed in paragraphs (d)(1)(ii) and (iii) of this section.

(ii) The inelastic behavior of concrete, based on the true variation of the modulus of elasticity with stress, shall be taken into account whenever its effect reduces the strength of the platform.

(iii) The geometric nonlinearities and the effect of initial deviation of the platform from the design geometry shall be taken into account whenever their effects reduce the strength of the platform.

(iv) Where appropriate, dynamic effects shall be taken into account. The dynamic response shall be determined by a defensible method that includes the effects of the foundation—platform interaction and the effective mass of the surrounding water.

(v) The material properties used in the analysis shall be based on actual laboratory tests or shall follow the appropriate sections of ACI 318.

(2) *Analysis of frames.* The analysis of frames shall be performed by a defensible method of structural mechanics. The buckling strength of the frame shall be assessed, and the safety against buckling failure shall be ensured to a degree consistent with the requirements in paragraphs (c)(2) and (c)(3) of this section.

(3) *Analysis of plates, shells, and folded plates.* The buckling strength of these plates shall be determined and a sufficient safety margin against instability shall be ensured.

(4) *Determination of deflections.* Deflections shall be determined by a defensible method. In addition to the immediate (instantaneous) deflections, the long-term deflections due to creep shall be accounted for.

(5) *Analysis and design for bending and axial loads.* The provisions of ACI 318 shall apply to the analysis and design of members subject to flexure or axial loads or to combined flexure and axial loads.

(6) *Analysis and design for shear and torsion.* The provisions of ACI 318 shall apply to the analysis and design of

members subject to shear or torsion or to combined shear and torsion.

(7) *Analysis and design of prestressed concrete.* The analysis and design of prestressed concrete members and structures shall comply with ACI 318. In addition, the safety requirements of paragraph (c) of this section shall be satisfied.

(8) *Details of reinforcement and prestressing systems.* Details of reinforcement and prestressing systems shall conform to the requirements of ACI 318 with special attention given to the fatigue resistance and ultimate behavior of offshore structures.

(9) *Minimum reinforcement.* The minimum amount of reinforcement shall conform to the requirements of ACI 318. Additionally, sufficient reinforcement shall be provided to control crack growth, especially at surfaces exposed to severe hydraulic pressures.

(10) *Concrete cover of reinforcement and prestressing tendons.* The concrete cover of reinforcement and prestressing tendons shall be sufficient to provide for corrosion protection of the steel.

(11) *Seismic analysis.* A dynamic analysis shall be performed to determine the response of the platform to design-earthquake loading. The platform shall be designed to withstand this loading without damage. In addition, a ductility check shall also be performed to ensure that the platform has sufficient ductility to experience deflections more severe than those resulting from the design-earthquake loading without the collapse of the platform or its foundation or any primary structural component.

(12) *Seismic design.* The design of structural members and details of platforms subjected to seismic loading shall ensure maximum ductility at critically loaded sections.

(e) *Construction—(1) General.* (i) Construction methods and workmanship shall conform to the provisions of ACI 318 and to the following requirements.

(ii) At each stage of construction, i.e., fabrication, initial flotation, towing, and installation in situ, the forces acting on the platform shall be kept within the safety limits listed in paragraph (c) of this section. Appropriate static and/or dynamic analysis shall be performed for the operating loading

conditions of each of the construction operations mentioned above. Buoyancy and stability shall be considered during all phases of construction.

(2) *Mixing, placing, and curing of concrete.* (i) Mixing of concrete must conform to the requirements of ACI Standard 318 and ASTM Standard C 94/C 94M-99, Standard Specification for Ready-Mixed Concrete;

(ii) When concreting in cold weather, the temperature of the fresh concrete shall be maintained sufficiently above freezing until the process of hardening is well in progress;

(iii) In hot weather, the temperature of the fresh concrete shall be controlled so that it does not impair attainment of the desired strength and durability;

(iv) The methods for curing concrete shall ensure maximum compressive and tensile strength, durability, and a minimum of cracking; and

(v) The location and workmanship of construction joints shall not impair the strength, crack resistance, and watertightness of the platform.

(3) *Reinforcement.* (i) Reinforcement shall be free from loose rust, grease, oil, deposits of salt, or any other material that may adversely affect the strength, durability, or bond of the reinforcement. The specified cover of reinforcement shall be maintained accurately. The cutting, bending, and fixing of reinforcement shall ensure that it is correctly positioned and rigidly held.

(ii) The welding of reinforcement shall conform to the requirements of AWS publication, AWS D1.4, Structural Welding Code—Reinforcing Steel.

(4) *Prestressing tendons, ducts, and grouting.* (i) Steps shall be taken to ensure that the achieved prestressing force is that specified in the design.

(ii) Tendons and ducts shall be in a condition that ensures the required strength, durability, and bond.

(iii) The grouting procedures shall produce the required bond strength of the tendons and provide permanent corrosion protection for the tendons. Anchorages shall also be protected adequately against corrosion.

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