780 CMR 19.00

CONCRETE

780 CMR 19.00 is Unique to Massachusetts

780 CMR 1901.0 GENERAL

1901.1 General. Structural concrete shall be designed and constructed in accordance with ACI 318, including all its appendices, except as provided otherwise in 780 CMR 19.00.

780 CMR 1902.0 THROUGH 1907.0 - RESERVED

780 CMR 1908.0 MODIFICATIONS TO ACI 318

1908.1 General. The text of ACI 318 shall be modified as indicated in 780 CMR 1908.1.1 through 1908.1.8

1908.1.1 ACI 318, Section 21.1. Modify existing definitions and add the following definitions to ACI 318, Section 21.1.

DESIGN DISPLACEMENT. Total lateral displacement expected for the design-basis earthquake, as specified by ASCE 7, Section 9.5.5.7 as modified by 780 CMR 1615.0.

STORY DRIFT RATIO. The design displacement over a story divided by the story height.

WALL PIER. A wall segment with a horizontal length-to-thickness ratio of at least 2.5, but not exceeding six, whose clear height is at least two times its horizontal length.

1908.1.2 ACI 318, Section 21.2.1. Modify Sections 21.2.1.2, 21.2.1.3 and 21.2.1.4. to read as follows:

21.2.1.2 For structures assigned to Seismic Design Category A or B, provisions of Chapters 1 through 18 and 22 shall apply except as modified by the provisions of this chapter. Where the seismic design loads are computed using provisions for intermediate or special concrete systems, the requirements of Chapter 21 for intermediate or special systems, as applicable, shall be satisfied.

21.2.1.3 For structures assigned to Seismic Design Category C, intermediate or special moment frames, or ordinary or special reinforced concrete structural walls shall be used to resist seismic forces induced by earthquake motions. Where the design seismic loads are computed using provisions for intermediate or special concrete systems, the requirements of Chapter 21 for intermediate or special systems, as applicable, shall be satisfied.

21.2.1.4 For structures assigned to Seismic Design Category D, special moment frames, special reinforced concrete structural walls, diaphragms and trusses and foundations complying with Sections 21.2 through 21.10 shall be used to resist forces induced by earthquake motions. Frame members not proportioned to resist earthquake forces shall comply with Section 21.11.

1908.1.3 ACI 318, Section 21.2.5. Modify ACI 318, Section 21.2.5, by renumbering as Section 21.2.5.1 and adding new Sections 21.2.5.2, 21.2.5.3 and 21.2.5.4 to read as follows:

21.2.5 Reinforcement in members resisting earthquake-induced forces.

21.2.5.1 *Except as permitted in Sections 21.2.5.2 through 21.2.5.4, reinforcement resisting earthquake-induced flexural and axial forces in frame members and in structural wall boundary elements shall comply with ASTM A 706. ASTM 615, Grades 40 and 60 reinforcement, shall be permitted in these members if (a) the actual yield strength based on mill tests does not exceed the specified yield strength by more than 18,000 psi (retests shall not exceed this value by more than an additional 3,000 psi), and (b) the ratio of the actual ultimate tensile strength to the actual tensile yield strength is not less than 1.25.*

21.2.5.2 *Prestressing steel shall be permitted in flexural members of frames, provided the average prestress, f_{pc}, calculated for an area equal to the member's shortest cross-sectional dimension multiplied by the perpendicular dimension shall be the lesser of 700 psi (4.83 MPa) or $f'_c/6$ at locations of nonlinear action where prestressing steel is used in members of frames.*

21.2.5.3 *Unless the seismic-force-resisting frame is qualified for use through structural testing as required by ACI T1.1, for members in which prestressing steel is used together with mild reinforcement to resist earthquake-induced forces, prestressing steel shall not provide more than one-quarter of the strength for either positive or negative moments at the nonlinear action location and shall be anchored at the exterior face of the joint or beyond.*

21.2.5.4 *Anchorages for tendons must be demonstrated to perform satisfactorily for seismic loadings. Anchorage assemblies shall withstand, without failure, a minimum of 50*

cycles of loading ranging between 40 and 85% of the minimum specified tensile strength of the prestressing steel.

1908.1.4 ACI 318, Section 21.7. Modify ACI 318, Section 21.7, by adding a new Section 21.7.10 to read as follows:

21.7.10 Wall piers and wall segments.

21.7.10.1 *Wall piers not designed as a part of a special moment frame shall have transverse reinforcement designed to satisfy the requirements in Section 21.7.10.2.*

Exceptions:

1. *Wall piers that satisfy Section 21.11.*
2. *Wall piers along a wall line within a story where other shear wall segments provide lateral support to the wall piers, and such segments have a total stiffness of at least six times the sum of the stiffness of all the wall piers.*

21.7.10.2 *Transverse reinforcement shall be designed to resist the shear forces determined from Sections 21.3.4.2 and 21.4.5.1. Where the axial compressive force, including earthquake effects, is less than $A_g f'c /20$, transverse reinforcement in wall piers is permitted to have standard hooks at each end in lieu of hoops. Spacing of transverse reinforcement shall not exceed six inches (152 mm). Transverse reinforcement shall be extended beyond the pier clear height for at least the development length of the largest longitudinal reinforcement in the wall pier.*

21.7.10.3 *Wall segments with a horizontal length-to-thickness ratio less than 2.5 shall be designed as columns.*

1908.1.5 ACI 318, Section 21.10.1.1. Modify ACI 318, Section 21.10.1.1, to read as follows:

21.10.1.1 *Foundations resisting earthquake-induced forces or transferring earthquake-induced forces between a structure and the ground shall comply with the requirements of Section 21.10 and other applicable provisions of ACI 318 unless modified 780 CMR 18.00.*

1908.1.6 ACI 318, Section 21.11. Modify ACI Sections 21.11.1 and 21.11.2.2 and add Sections 21.11.5 through 21.11.7 as follows:

21.11.1 *Frame members assumed not to contribute to lateral resistance shall be detailed according to Section 21.11.2 or 21.11.3 depending on the magnitude of moments induced in those members when subjected to the design displacement. If effects of design displacements are not explicitly checked, it shall be permitted to apply the requirements of Section 21.11.3. Slab-column connections shall comply with Sections 21.11.5 through 21.11.7. Conformance to Section 21.11 satisfies the deformation compatibility requirements of Section 9.5.2.2.4.3 of ASCE 7.*

21.11.2.2 *Members with factored gravity axial forces exceeding ($A_g f'_c /10$) shall satisfy Sections 21.4.3, 21.4.4.1(c), 21.4.4.3 and 21.4.5. The maximum longitudinal spacing of ties shall be, s_o, for the full column height. The spacing, s_o, shall not be more than six diameters of the smallest longitudinal bar enclosed or six inches (152 mm), whichever is smaller. Lap splices of longitudinal reinforcement in such members need not satisfy Section 21.4.3.2 in structures where the seismic-force-resisting system does not include special moment frames.*

21.11.5 *Reinforcement to resist punching shear shall be provided in accordance with Sections 21.11.5.1 and 21.11.5.2 at slab column connections where story drift ratio exceeds [0.035 – 0.05 ($V_u /\phi V_c$)] except that Sections 21.11.4.1 and 21.11.4.2 need not be satisfied where $Vu/\phi V_c$ is less than 0.2 or where the story drift ratio is less than 0.005. Vu equals the factored punching shear from gravity load excluding shear stress from unbalanced moment. Vu is calculated for the load combination 1.2D + 1.0L + 0.5S. The load factor on L is permitted to be reduced to 0.5 in accordance with Section 9.2.1(a). In no case shall shear reinforcement be less than that required in Section 11.12 for loads without consideration of seismic effects.*

21.11.5.1 *— The slab shear reinforcement shall provide V_s not less than $3.5(f'c)^{1/2}$.*

21.11.5.2 *— Slab shear reinforcement shall extend not less than five times the slab thickness from the face of column.*

21.11.6 *— Bottom bars or wires within the column strip shall conform to Section 13.3.8.5 except that splices shall be Class B.*

21.11.7 *— Within the effective slab width defined in Section 13.5.3.2, the ratio of non-prestressed bottom reinforcement to gross concrete area shall not be less than 0.004. Where bottom reinforcement is not required to be continuous, such reinforcement shall extend a minimum of five times the slab thickness plus one development length beyond the face of the column or shall be terminated at the slab edge with a standard hook.*

1908.1.7 ACI 318, Section 21.12.5. Add Section 21.12.5.6 and modify ACI 318, Sections 21.12.5.1, 21.12.5.2 and 21.12.5.5, to read as follows:

21.12.5.1 *--- Columns shall be spirally reinforced in accordance with 7.10.4 or shall conform with 21.12.5.2 through 21.12.5.4. Sections 21.12.5.5 and 21.12.5.6 shall apply to all columns.*

21.12.5.2 *At both ends of the member, hoops shall be provided at spacing* s_o *over a length* l_o *measured from the joint face. Spacing* s_o *shall not exceed the smallest of (a), (b), (c) and (d):*

(a) Six times the diameter of the smallest longitudinal bar enclosed;

(b) 12 times the diameter of the hoop bar;

(c) ¼ of the smallest cross-sectional dimension of the frame member;

(d) six in.

Length l_o *shall not be less than the largest of (e), (f), and (g):*

(e) One-sixth of the clear span of the member;

(f) Maximum cross-sectional dimension of the member;

(g) 18 in.

21.12.5.5 *--- Joint transverse reinforcement shall conform to 11.11.2. Where transverse joint reinforcement is required, such reinforcing shall be hoops. The spacing* s_o *of hoops shall not exceed the smallest of (a), (b), (c) and (d) as defined in 21.12.5.2.*

21.12.5.6 *--- Mechanical splices shall conform to 21.2.6 and welded splices shall conform to 21.2.7. Lap splices of longitudinal reinforcement shall be permitted only within the center half of the member length and shall be designed as tension splices.*

1908.1.8 ACI 318, Section 21.13.2. Modify ACI 318, Section 21.13.2, to read as follows:

21.13.2 *In connections between wall panels, or between wall panels and the foundation, yielding shall be restricted to reinforcement.*

1908.2 Table 4.2.1 of ACI 318. For the purposes of this table, severe and moderate exposures shall be defined as follows:

1. Severe exposure occurs where concrete will be in almost continuous contact with moisture prior to freezing, or where deicing salts are used. Examples are pavements, bridge decks, sidewalks, parking garages and water tanks.

2. Moderate exposure occurs where concrete will be only occasionally exposed to moisture prior to freezing, and where deicing salts are not used. Examples are certain exterior walls, beams, girders and slabs not in direct contact with soil.

780 CMR 1909.0 – RESERVED

780 CMR 1910.0 SEISMIC DESIGN PROVISIONS

1910.1 General. The design and construction of concrete components that resist seismic forces shall conform to the requirements of 780 CMR 1910.0 and to ACI 318 except as modified by 780 CMR 1908.0.

1910.2 Classification of Shear Walls. Structural concrete shear walls that resist seismic forces shall be classified in accordance with 780 CMR 1910.2.1 through 1910.2.4.

1910.2.1 Ordinary Plain Concrete Shear Walls. Ordinary plain concrete shear walls are not permitted.

1910.2.2 Detailed Plain Concrete Shear Walls. Detailed plain concrete shear walls are not permitted.

1910.2.3 Ordinary Reinforced Concrete Shear Walls. Ordinary reinforced concrete shear walls are walls conforming to the requirements of ACI 318 for ordinary reinforced concrete structural walls. Shear forces due to seismic loads in ordinary reinforced concrete shear walls and coupling beams shall be increased by 50% in all applicable load combinations.

1910.2.4 Special Reinforced Concrete Shear Walls. Special reinforced concrete shear walls are walls conforming to the requirements of ACI 318 for special reinforced concrete structural walls or special precast structural walls.

1910.3 Seismic Design Category B. Structures assigned to Seismic Design Category B, as determined in 780 CMR 16.00, shall conform to the requirements for Seismic Design Category A and to the additional requirements for Seismic Design Category B of 780 CMR 1910.3.

1910.3.1 Ordinary Moment Frames. Ordinary moment frames are not permitted.

1910.4 Seismic Design Category C. Structures assigned to Seismic Design Category C, as determined in 780 CMR 16.00, shall conform to the requirements for Seismic Design Category B and to the additional requirements for Seismic Design Category C of this Section.

1910.4.1 Seismic-force-resisting Systems. Moment frames used to resist seismic forces shall be intermediate moment frames or special moment frames. Shear walls used to resist seismic forces shall be ordinary reinforced concrete shear walls or special reinforced concrete shear walls. Ordinary reinforced concrete shear walls constructed of precast concrete elements shall comply with the additional requirements of ACI 318, Section 21.13 for intermediate precast concrete structural walls, as modified by 780 CMR 1908.1.8.

1910.4.2 Discontinuous Members. Columns supporting reactions from discontinuous stiff members, such as walls, shall be designed for the special load combinations in 780 CMR 1605.0 and shall be provided with transverse reinforcement at the spacing, s_o, as defined in ACI 318, Section 21.12.5.2 over their full height beneath the level at which the discontinuity occurs. This transverse reinforcement shall be extended above and below the column as required in ACI 318, Section 21.4.4.5.

1910.4.3 Plain Concrete. Structural plain concrete members are not permitted

1910.4.3.1 Walls. Structural plain concrete walls are not permitted.

1910.4.3.2 Footings. Isolated footings of plain concrete supporting pedestals or columns are permitted provided the projection of the footing beyond the face of the supported member does not exceed the footing thickness.

Plain concrete footings supporting walls are permitted provided that the projection of the footing beyond the face of the wall does not exceed the footing thickness. Such footings shall be provided with not less than two continuous longitudinal reinforcing bars. Bars shall not be smaller than No. 5 and shall have a total area of not less than 0.002 times the gross cross-sectional area of the footing.

Reinforcing steel dowels shall extend from the plain concrete footings into the supported pedestals, columns, or walls in accordance with Sections 21.10.2.1 and 21.10.2.3 of ACI 318.

1910.4.3.3 Pedestals. Plain concrete pedestals shall not be used to resist lateral seismic forces.

1910.5 Seismic Design Category D. Structures assigned to Seismic Design Category D, as determined in 780 CMR 16.00, shall conform to the requirements for Seismic Design Category C and to the additional requirements of 780 CMR 1910.5.

1910.5.1 Seismic-force-resisting Systems. Moment frames used to resist seismic forces shall be special moment frames. Shear walls used to resist seismic forces shall be special reinforced concrete shear walls.

1910.5.2 Frame Members Not Proportioned to Resist Forces Induced by Earthquake Motions. Frame components assumed not to contribute to lateral force resistance shall conform to ACI 318, Section 21.11 as modified by 780 CMR 1908.1.6.

780 CMR 1911.0 MINIMUM SLAB PROVISIONS

1911.1 General. The thickness of concrete floor slabs supported directly on the ground shall not be less than four inches (102 mm).

See 780 CMR 13.00 for vapor barrier requirements under the slab.

780 CMR 1912.0 - RESERVED

780 CMR 1913.0 ANCHORAGE TO CONCRETE

1913.1 Post-installed Adhesive Anchors. Post-installed adhesive anchors in structural concrete (the criteria for which are excluded from Appendix D of ACI 318 by Section D.2.2) shall comply with ICC ES AC308.

1913.2 Acceptance Criteria for Post-installed Anchors.

1913.2.1 Independent Evaluation. All post-installed anchors shall be evaluated by the ICC Evaluation Service, Inc. (ICC ES) or by other accredited independent testing agencies approved by the BBRS, for compliance with 780 CMR. The ICC ES or the independent testing agencies shall provide an evaluation report that shall be made public and readily available to the public either directly or through the manufacturer requesting the evaluation. The evaluation report shall state all limitations on use.

1913.2.2 Review by the Design Professional. The registered design professional for the structural design shall obtain and evaluate the applicable evaluation reports for the anchors specified in the structural design. Anchors shall not be specified for use beyond the limitations given in the evaluation report.

780 CMR 1914.0 SHOTCRETE

1914.1 General. Shotcrete is mortar or concrete that is pneumatically projected at high velocity onto a surface. Except as specified in this section, shotcrete shall conform to the requirements of this chapter for plain or reinforced concrete.

1914.2 Proportions and Materials. Shotcrete proportions shall be selected that allow suitable placement procedures using the delivery equipment selected and shall result in finished in-place hardened shotcrete meeting the strength requirements of 780 CMR.

1914.3 Aggregate. Coarse aggregate, if used, shall not exceed ¾ inch (19.1 mm).

1914.4 Reinforcement. Reinforcement used in shotcrete construction shall comply with the provisions of 780 CMR 1914.4.1 through 1914.4.4.

1914.4.1 Size. The maximum size of reinforcement shall be No. 5 bars unless it is demonstrated by preconstruction tests that adequate encasement of larger bars will be achieved.

1914.4.2 Clearance. When No. 5 or smaller bars are used, there shall be a minimum clearance between parallel reinforcement bars of 2½ inches (64 mm). When bars larger than No. 5 are permit-

ted, there shall be a minimum clearance between parallel bars equal to six diameters of the bars used. When two curtains of steel are provided, the curtain nearer the nozzle shall have a minimum spacing equal to 12 bar diameters and the remaining curtain shall have a minimum spacing of six bar diameters.

Exception. Subject to the approval of the responsible registered design professional, required clearances may be reduced where it is demonstrated by preconstruction tests that adequate encasement of the bars used in the design will be achieved.

1914.4.3 Splices. Lap splices of reinforcing bars shall utilize the noncontact lap splice method with a minimum clearance of two inches (51 mm) between bars. The use of contact lap splices necessary for support of the reinforcing is permitted when approved by the building official, based on satisfactory preconstruction tests that show that adequate encasement of the bars will be achieved, and provided that the splice is oriented so that a plane through the center of the spliced bars is perpendicular to the surface of the shotcrete.

1914.4.4 Spirally Tied Columns. Shotcrete shall not be applied to spirally tied columns.

1914.5 Preconstruction Tests. When required by the responsible registered design professional, a test panel shall be shot, cured, cored or sawn, examined and tested prior to commencement of the project. The sample panel shall be representative of the project and simulate job conditions as closely as possible. The panel thickness and reinforcing shall reproduce the thickest and most congested area specified in the structural design. It shall be shot at the same angle, using the same nozzleman and with the same concrete mix design that will be used on the project. The equipment used in preconstruction testing shall be the same equipment used in the work requiring such testing, unless substitute equipment is approved by the responsible registered design professional.

1914.6 Rebound. Any rebound or accumulated loose aggregate shall be removed from the surfaces to be covered prior to placing the initial or any succeeding layers of shotcrete. Rebound shall not be used as aggregate.

1914.7 Joints. Except where permitted herein, unfinished work shall not be allowed to stand for more than 30 minutes unless edges are sloped to a thin edge. For structural elements that will be under compression and for construction joints shown on the approved construction documents, square joints are permitted. Before placing additional material adjacent to previously applied work, sloping and square edges shall be cleaned and wetted.

1914.8 Damage. In-place shotcrete that exhibits sags, sloughs, segregation, honeycombing, sand pockets or other obvious defects shall be removed and replaced. Shotcrete above sags and sloughs shall be removed and replaced while still plastic.

1914.9 Curing. During the curing periods specified herein, shotcrete shall be maintained above 40°F (4°C) and in moist condition.

1914.9.1 Initial Curing. Shotcrete shall be kept continuously moist for 24 hours after shotcreting is complete or shall be sealed with an approved curing compound.

1914.9.2 Final Curing. Final curing shall continue for seven days after shotcreting, or for three days if high- early-strength cement is used, or until the specified strength is obtained. Final curing shall consist of the initial curing process or the shotcrete shall be covered with a moisture-retaining cover approved by the responsible registered design professional.

1914.9.3 Natural Curing. Natural curing shall not be used in lieu of that specified in this section unless the relative humidity remains at or above 85%, and is authorized by the responsible registered design professional.

1914.10 Strength Tests. Strength tests for shotcrete shall be made by an approved agency on specimens that are representative of the work and which have been water soaked for at least 24 hours prior to testing. When the maximum size aggregate is larger than ⅜ inch (9.5 mm), specimens shall consist of not less than three-inch (76 mm) diameter cores or three-inch (76 mm) cubes. When the maximum size aggregate is ⅜ inch (9.5 mm) or smaller, specimens shall consist of not less than two-inch (51 mm) diameter cores or two-inch (51 mm) cubes.

1914.10.1 Sampling. Specimens shall be taken from the in-place work or from test panels, and shall be taken at least once each shift, but not less than one for each 50 cubic yards (38.2 m^3) of shotcrete.

1914.10.2 Panel Criteria. When the maximum size aggregate is larger than ⅜ inch (9.5 mm), the test panels shall have minimum dimensions of 18 inches by 18 inches (457 mm by 457 mm). When the maximum size aggregate is ⅜ inch (9.5 mm) or smaller, the test panels shall have minimum dimensions of 12 inches by 12 inches (305 mm by 305 mm). Panels shall be shot in the same position as the work, during the course of the work and by the nozzlemen doing the work. The conditions under which the panels are cured shall be the same as the work.

1914.10.3 Acceptance Criteria. The average compressive strength of three cores from the in-place work or a single test panel shall equal or exceed 0.85 f'_c with no single core less than 0.75 f'_c. The average compressive strength of three cubes taken from the in-place work or a single test

panel shall equal or exceed f'_c with no individual cube less than 0.88 f'_c. To check accuracy, locations represented by erratic core or cube strengths shall be retested.

780 CMR 1915.0 REINFORCED GYPSUM CONCRETE

1915.1 General. Reinforced gypsum concrete shall comply with the requirements of ASTM C 317 and ASTM C 956.

1915.2 Minimum Thickness. The minimum thickness of reinforced gypsum concrete shall be two inches (51 mm) except the minimum required thickness may be reduced to 1½ inches (38 mm), provided the following conditions are satisfied:

1. The overall thickness, including the formboard, is not less than two inches (51 mm).
2. The clear span of the gypsum concrete between supports does not exceed 33 inches (838 mm).
3. Diaphragm action is not required.
4. The design live load does not exceed 40 psf (1915 Pa).

780 CMR 1916.0 CONCRETE-FILLED PIPE COLUMNS

1916.1 General. Concrete-filled pipe columns shall be manufactured from standard, extra-strong or double-extra-strong steel pipe or tubing that is filled with concrete so placed and manipulated as to secure maximum density and to ensure complete filling of the pipe without voids.

1916.2 Design. The safe supporting capacity of concrete-filled pipe columns shall be computed in accordance with ACI 318-02, Section 10.16.6 or AISC LRFD, Section 12 or determined by tests.

1916.3 Fire-resistance-rating Protection. Pipe columns shall be of such size or so protected as to develop the required fire-resistance ratings specified in Table 601. Where an outer steel shell is used to enclose the fire-resistive covering, the shell shall not be included in the calculations for strength of the column section. The minimum diameter of pipe columns shall be four inches (102 mm) except that in structures of Type V construction not exceeding three stories or 40 feet (12 192 mm) in height, pipe columns used in the basement and as secondary steel members shall have a minimum diameter of three inches (76 mm).