2025 ICC 1150 Permissive to mandatory verbiage revisions in the following sections of the final draft

301.3 Material Mixing and Curing. For qualification or acceptance of the *3D printing material*, the environmental conditions of the mixing room and curing water shall meet ASTM C511. The raw materials listed in the mixture design including the mixing water shall be conditioned to room temperature before mixing. Mixing of *3D printing concretes* shall be performed in accordance with ASTM C192/C192M, while mixing of *3D printing mortars* shall be performed in accordance with ASTM C305. For *pre-packaged 3D printing material*, the requirements of mixing and water content listed on the product technical datasheet (TDS) shall be followed. The *3D printing materials* shall be cured in the laboratory in accordance with ASTM C192/C192M prior to testing in accordance with **Error! Reference source not found.**.

401.2.2 Structural Testing. Wall systems shall meet the minimum detailing requirements of **Error! Reference source not found.** and the connection requirements of **Error! Reference source not found.** unless structural testing is performed demonstrating that an alternative method provides equal to or better performance than the minimum requirements outlined in **Error! Reference source not found.** and **Error! Reference source not found.**. As an option, determination of the structural design of *3D-ACT* wall systems shall consist of the alternative testing requirements of **Error! Reference source not found.**.

401.2.3 Structural Analysis. The effects of slenderness, including both the individual member slenderness and the structure's deflection, shall be considered where a first-order elastic analysis that satisfies equilibrium using the original undeformed geometry of the structure is used.

401.3.2.3 Non-Load Bearing Walls. Non-load structural walls without integral cores shall be designed where lateral support or stability of the wall is demonstrated through rational analysis.

403.4.1 Single-Shell Walls. Integral *cores* shall be connected to the *shell* by means of a cross tie(s) with two legs that encapsulates the core area and vertical reinforcement. *Core* cross-ties shall consist of a minimum wire diameter of W2.8 (3/16 in. [4.8 mm]) and shall be spaced at a distance not to exceed 12 in. (300 mm) on-center. Cross-ties shall not be required where a rational analysis shows that the horizontal shear demands between the core and the shell is not greater than 80 psi (550 kPa).

403.5 Minimum Connections Between Shells. Multi-shell *3D-ACT* wall systems shall contain minimum cross-ties connecting the *shells* in accordance with this section. For *cavity* widths not exceeding 4 in. (100 mm), cross ties shall consist of a minimum wire diameter of W1.7 (0.148 in. [3.76 mm]) spaced not greater than 16 in. (400 mm) on-center in both directions. For *cavity* widths greater than 4 in. (100 mm) but not exceeding 6 in. (150 mm), cross ties shall consist of a minimum diameter of W2.8 (3/16 in. [4.8 mm]) spaced not greater than 16 in. (400 mm) on-center in both directions. As an option, *cavity* widths and cross tie configurations shall be used where verified by a detailed tie analysis or structural testing considering both positive and negative design pressures. Where cross ties are required, the detailing, including hooks and anchorages, shall transfer the design tensile and compressive loads.

Table 403.7

[a] As an option, alternative methods of protecting the reinforcement from weather shall be provided if they satisfy the additional concrete cover requirements of this standard.

403.8 Minimum Core Fill Dimensions. For a *core* fill placement height of not greater than 12 ft. (3.7 m), with a maximum aggregate size of 1/2 in. (12.7 mm), the minimum *core* fill area shall be 9 sq. in. (5800 sq. mm), and the minimum clear dimension shall be 2-1/2 in (64 mm). Where a larger maximum aggregate size is used, minimum clear dimensions shall be in accordance with ACI CODE-318, Section 25.2.1. Splices shall be considered where determining the minimum clear dimensions.

For fill heights exceeding 12 ft. (3.7 m) and fill dimensions less than those specified above, the results of a *core* fill shall demonstrate that the *cores* are filled and consolidated. The procedures used in constructing the *core* fill

demonstration shall meet the minimum requirements for *core* filling, and the quality assurance program shall include inspection during construction to verify *core* fill placement.

404.2.3.3 Modulus of Elasticity. The design modulus of elasticity, Es, shall be 29,000,000 psi (200 GPa).

404.2.3.4 Yield Strain. The yield strain, ε_{ty}, shall be equal to f_y/E_s. For Grade 60 deformed reinforcement, it shall be equal to 0.002.

404.3.1.1 Presumptive Values. Where there is no published *effective structural contact width* based on measurements, the following shall be used to determine the *effective structural contact width* based on the nominal *bead* width. If the nominal *bead* width is not given or defined, the designer shall assume and justify a nominal *bead* width.

404.3.1 Effective Structural Contact Width. The *effective structural contact width* shall be a function of the nominal *bead* width. The *effective structural contact width* between multiple *beads* of *3D-ACT* wall systems shall be defined in Figure 404.3.1. The design shall be performed using the presumptive *effective structural contact width* in Section 404.3.1.1 or the measure *effective structural contact width* as defined in Section 404.3.1.2. Where the *print path* includes offsets of one *bead* relative to the one below it for creating textured walls, the *effective structural contact width* shall account for the offset.

404.3.2 Effective Side Face Contact. Where multiple *beads* make up a single *shell*, integral *cores* contact the *shell*, and webbing contacts the *shells* the *effective side face contact* between multiple *beads* of *3D-ACT* wall systems shall be as defined in Figure 404.3.1. Integral *cores* and webbing shall have *effective side face contact*. Refer to Sections **Error! Reference source not found.** and **Error! Reference source not found.**. Design shall be based on presumptive values in Section 401.3.2.1 or measured values as defined in Section 404.3.2.2.

404.3.4 Flexural Moment of Inertia. Deflection calculations for unreinforced elements shall be based on uncracked, gross section properties. Deflection calculations for reinforced elements shall be based on cracked section properties. Where multiple materials of differing stiffnesses make up the cross section, the lower stiffness material shall be assumed to make up the entire section. As an option, transformed section properties shall be used. The flexural stiffness properties assumed for deflection calculations shall not exceed one-half of the gross section properties, unless a cracked-section analysis is performed.

404.4.1 Effective Flange Width. For analysis of integral *cores*, the effective width of the *shell(s)* shall be considered in the calculation of the flexural capacity of the *core*. The effective *shell* width of the section shall be in accordance with Table 404.4.1. Effective *shell* width shall be no larger than the core spacing.

404.4.2.1 Span. *Shells* shall be simply supported between vertical elements for out-of-plane flexural loads. No multi-span analysis of the shells shall occur.

404.5.4 Combined Moment and Axial Loads. *3D-ACT* wall systems shall be designed for combined moment and axial loads. Load-bearing walls shall be designed for the maximum strength-level moment, which accompanies the strength-level axial load for each applicable load combination. Where the strength-level axial load is less than $0.10f_c'A_g$ and located within $h_{eff}/6$ of cross-section's centroid, the axial loads shall be neglected and the section shall be designed for moment only.

Where the combined effects of moment and axial loads shall be considered, the nominal capacity of the wall shall be determined following the assumptions given in ACI CODE-318, Section 22.2 to create an axial-moment interaction diagram. The axial-moment interaction diagram shall not exceed the axial capacity determined in accordance with Section **Error! Reference source not found.**.

406.1 General. The design and detailing of structural elements of *3D-ACT* wall systems, including their connections to other structural elements, shall be in accordance with the engineering design in Sections 403, 404, and, where

applicable, 405. As an option, determination of the structural design of *3D-ACT* wall systems shall be in accordance with the alternative testing requirements of this section. This shall include one or a combination of, the complete structural testing described in Section **Error! Reference source not found.**, anchor testing described in Section 0 or select supplemental testing and engineering design described in Section 0. Where deviations to the engineering design are used, testing shall show that the alternative method provides equal or better performance than the minimum requirements outlined in **Error! Reference source not found.**, **Error! Reference source not found.**, and **Error! Reference source not found.**.

406.3.2.5 Static In-Plane Shear Tests. A minimum of three replicate specimens with the minimum total wall thickness shall be tested. If multiple wall thicknesses are being evaluated, an additional three replicate specimens of the maximum total wall thickness to be considered shall be tested.

Shear tests shall be performed based on the racking load procedure described in Section 14 of ASTM E72. For these tests, the loading procedure shall be modified to apply the lateral racking through a continuous, reinforced concrete or steel member. The attachment to the specimen shall be designed so that applied loads are uniformly distributed along the specimen length. The specimen shall be mounted on a base in accordance with generally accepted methods used in the field that prevents concentrated reactions. In this regard, the specimen shall be attached to the base to prevent concentrated reactions.. Where the vertical load does not resist the overturning moment, anchorage shall be incorporatedused. The procedures and details of testing on the product or system shall be documented in the Engineered Design Guidelines Report. Calculations and reporting shall be in accordance with Section 14.5 of ASTM E72.

As an option for 3D-ACT wall systems consisting of two outer face shells and fully filled to form a solid wall, diagonal tension (shear) tests shall be performed in accordance with the diagonal shear test procedure as defined in ASTM E519. The ultimate shear stress, ultimate shear strain, and modulus of rigidity for each specimen shall be reported in accordance with ASTM E519.

406.3.3.1 Analysis of Test Results. Where analyzing and interpreting the full-scale structural testing, the average maximum strength from each set of replicate tests shall be the average ultimate value, provided the ultimate value for each test is within 15 percent of the average. Otherwise, the lowest ultimate value of the replicate tests shall be used.

406.3.3.2.1 Design Methodologies. Alternatives to the *Engineered Design Guidelines* report shall include relating the load-resistance rating to design code equations, models, and techniques from ACI CODE-318, TMS 402/602, or other applicable codes. Existing code equations and models shall be modified by appropriate strength reduction factors to verify or modify the existing design equations used to determine characteristic strengths of the *3D-ACT* wall system. The design strength of the *3D-ACT* wall system defined in the *Engineered Design Guidelines Report* shall be not greater than that determined using the strength reduction factors in ACI CODE-318.

406.4 Fastener and Anchor Testing. The capacity of anchors in *3D printing materials* are code alternatives and shall be determined in accordance with ICC ES AC01, AC58, AC60, AC70, AC106, AC193, AC308, AC398, AC510 and AC545, as applicable. A Summary Test Report shall be generated that includes a summary of the anchor testing performed, including the specimen geometry and details, specimen fabrication, testing equipment and protocol. Deviations or adjustments to the standard test method(s) shall be noted. The Summary Test Report shall be available to the administrative authority adopting this standard.

406.5 Additional Supplemental Testing. Where the assessment of specific engineering properties or behaviors is applicable, supplemental testing shall consist of material testing, small-scale structural testing, or full-scale structural testing. Where possible, testing shall follow appropriate ASTM test methods, with the results and any modifications included in the test report. A Summary Test Report shall be generated and shall include a summary of the testing performed, including the specimen geometry and details, specimen fabrication, testing equipment and protocol. Deviations or adjustments to the standard test method(s) shall be noted. Where the testing is to validate an alternative to the requirements of Sections 403, 404, and 405, the test report shall demonstrate that the alternative provides equal

to or better performance than the minimum requirements outlined in Sections 403, 404, and 405. The Summary Test Report shall be available to the administrative authority adopting this standard. As an option other supplemental testing shall be provided to accompany the testing described in Section **Error! Reference source not found.** or to validate alternatives to the engineering design described in **Error! Reference source not found.**, **Error! Reference source not found.**, and **Error! Reference source not found.**.

501.4 Printing Process. *3D printing material* batching, mixing, and printing shall be in accordance with the material supplier and producer's operating procedures with the following requirements. The time between *layer* extrusions shall be the typical interlayer print time except for:

1. The delay between print *layers* 8 and 9, and 10 and 11 shall be the maximum interlayer print time that will be used during construction without application of bonding agent or special surface preparation between printing *layers*. During prequalification, there shall not be application of a bonding agent or special surface preparation between printing *layers* 8 and 9, and 10 and 11.
2. A print stop of no less than 8 hours shall be incorporated between *layers* 9 and 10. The producer's print stop interlayer protocol shall be followed prior to resuming printing. The print stop protocol shall consist of the application of a bonding agent or other applicable surface preparation techniques where used in the construction. The protocol shall be documented as part of the submittal and incorporated into the construction documents.

3D printing material produced at the plant of a ready-mixed concrete supplier shall conform to the requirements of ASTM C94/C94M. *3D printing material* produced using volumetric batching shall conform to the requirements of ASTM C685/C685M. Material batching, mixing, delivery, and printing for the prequalification elements shall be consistent with temperature and relative humidity conditions anticipated during construction.

The methods used for curing and protection shall be identical to those used for the specific construction project. Where specific protection and curing methods are implemented, they shall be documented as part of the submittal and incorporated into the construction documents.

501.6.2.1 Workability. The workability of the freshly mixed *3D printing material* shall be determined in accordance with ASTM C1437 for *3D printing mortar* and in accordance with ASTM C143/C143M for *3D printing concrete*. Where ASTM C1437 is used, a steel mounting plate with a minimum thickness of 3/4 in. (19 mm) and a minimum weight of 35 lb. (16 kg) shall be used.

501.6.3.3 Interlayer Tensile Bond Strength. No fewer than 24 specimens, 12 for each prequalification element, shall be tested in accordance with ASTM C1583 as modified herein.

Test specimens shall be sawn from the double-*bead* portions of the prequalification elements and shall contain no fewer than six *layers*, with the 8 hour print stop at the top 1/3 height of the specimens. Specimens shall be not less than 16 in. (400 mm)] in length. Where *core* drilling vertically for ASTM C1583 pull-off testing, the testing specimens shall be secured. Coring shall penetrate no fewer than three interfaces, including the 8 hour stop *layer*.

Pull-off testing shall use test discs with a diameter not greater than 90 percent of the single-*bead effective structural contact width*. The *core* barrel's inner diameter shall be identical to the diameter of the test disc. The distance from the center of a tensile bond test to a free edge shall be less than 2 in. (50 mm). Tests shall be reported as individual results. The failure load, test diameter, and failure type shall be reported. Tests including the overnight print stop shall be designated.

501.6.3.4 Additional Testing. Additional tests and test methods shall be performed at the discretion of the material supplier, producer, or both but are not required for field prequalification.

502.2.2 Bead Geometry, Wall Geometry, and Reinforcement. Concurrent to the special inspection of the *3D printing materials*, the following shall be periodically verified for accordance to the contract documents:

1) *Bead* geometry. Verification shall include confirming the *bead* height and width conforms with the contract documents. Locations of tears and under-extrusion shall be documented and reported.
2) Wall dimensions. Verification of overall wall dimensions shall include confirming the nominal thickness conforms with the contract documents. *Bead* misalignment, wall out-of-plumbness, or both shall be documented and reported.
3) Horizontal reinforcement. Where horizontal reinforcement is being placed while periodic inspections of the *3D printing materials* are occurring, verification of horizontal reinforcement shall include confirming size, grade, and placement.
4) Cross ties. Where cross ties are being placed while periodic inspections of the *3D printing materials* are occurring, verification of cross ties shall include confirming size, grade, and placement.
5) Vertical reinforcement. Where vertical reinforcement is verified and inspected prior to embedment and concealment in the *core* filling material, special inspection of the reinforcement shall occur no less than once during or prior to a structure's *core* filling operations.

Where any welding of reinforcing bars is performed as part of the 3D-printed construction, the welding shall have continuous special inspection in accordance with the adopted building code.

502.4.2 Workability. The workability of the *3D printing material* shall be determined in accordance with ASTM C1437 for flow of *3D printing mortar* or in accordance with ASTM C143/C143M for slump of *3D printing concrete*. Where ASTM C1437 is used a steel mounting plate with a minimum thickness of ¾ in. [19 mm] and a minimum weight of 35 lbf (16 kg) shall be used.