



US Army Corps
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ENGINEERING AND CONSTRUCTION BULLETIN

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SUBJECT: Design and Construction of 3D Printed (Additive Construction) Concrete Structures

CATEGORY: Policy and Guidance

1. References:

- a. UFC 3-301-01 “Structural Engineering”, dated 10-01-2019
- b. UFC 1-200-01 “DoD Building Code, with Change 1”, dated 10-08-2019
- c. ECB 2021-5 “Interpretation of UFC 1-200-01, Delegation of Building Official/Authority Having Jurisdiction (BO/AHJ) Responsibilities, and Waiver/Exemption/Equivalency Approvals”, dated 04-20-2021

2. **Purpose.** This Engineering and Construction Bulletin (ECB) provides policy and guidance for the design and construction of 3D Printed Concrete Structures. 3D Printed Concrete Structures will be referred to as “additive construction” for the remainder of this ECB.

3. **Applicability.** This ECB applies to HQUSACE elements, major subordinate commands, districts, laboratories, and field operating activities. This ECB only applies to occupied additive construction structures.

4. **Background.** The methods of design and construction using additive construction is an emerging industry. The Tri-Service Structural Design Working Group has been tasked with developing a UFC and UFGS to support utilization of this technology. Currently, there are no comprehensive industry codes, guidance or criteria. ACI and ASTM have committees that are in the process of developing standards and codes. ERDC-CERL is involved with ACI and ASTM and they are currently conducting research on many aspects of additive construction. The current state of the industry is a group of independent companies that have proprietary materials, processes and procedures. Academic research is accessible but is limited in scale and materials and construction methods varies between research institutions.

5. **Policy.** An occupied structure is considered a life safety issue, therefore the Chief, Engineering & Construction, HQUSACE, or their designee, must approve equivalencies involving additive construction per ECB 2021-5. Although the use of additive construction is allowed under section 104.11 of UFC 1-200-01, any additive construction structure that will be occupied and/or houses high value and/or mission critical equipment (as determined by the installation Commander or AHJ), will be approved by the Chief of Engineering and Construction, HQUSACE. Un-reinforced additive construction will not be considered. Additive construction will not be used for Risk Category III, IV or V buildings. Dynamic “shake table” testing that replicates the anticipated seismic loading is required, static testing or finite element

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analysis is not acceptable. In addition, the additive construction structure must meet all requirements contained in the structural UFC and the DoD Building Code UFC.

6. Implementation. It is the responsibility of the submitter of a proposed project to demonstrate life safety equivalency to established concrete construction means, methods and materials. This includes, but not limited to, equivalency for quality, strength, effectiveness, fire resistance, durability, and safety. It is also the responsibility of the submitter to show that the structure has the capacity to resist all design loads and applicable design load combinations. All testing must be performed by an independent third party. All testing will be done on printed samples that are loaded parallel, perpendicular, and transverse to the extrusion direction. The submission for a proposed project must include, but is not limited to, the following:

- a. Full description of concrete mix. How will mix differ from region to region?
- b. Full description of QA/QC procedures.
- c. Discussion of long-term effects, i.e., creep and fatigue.
- d. Discussion of hot and cold weather requirements.
- e. Effectiveness of rebar bonding and effect on development lengths.
- f. Full stamped specifications and plans.
- g. Name and qualifications of the structural engineer of record.
- h. Drilled core and sawed beam testing to ASTM C42i. Testing of connections (if applicable).
- i. Pull out anchor testing.
- j. Fire testing.
- k. Thermal testing (R-value).
- l. Environmental testing, outdoor conditions.
- m. Full stamped design analysis including any computer modelling.
- n. Any special inspections required during construction.

HQUSACE will solicit CERL and/or other entities for assistance in its review and approval process.

7. Point of Contact. HQUSACE point of contact for this ECB is Richard Ludwitzke, CECW-EC, (202) 761-1580, Richard.j.Ludwitzke@usace.army.mil.

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PETE G. PEREZ, P.E.
Chief, Engineering and Construction Division
Directorate of Civil Works