REPORT TO CONGRESS

Integration of Innovative Construction Materials

Office of the Assistant Secretary of Defense for Energy, Installations, and Environment

May 2025

The explanatory statement accompanying H.R. 2617, the Consolidated Appropriations Act, 2023, division J, page 5.

The estimated cost for this report or study for the Department of Defense is approximately $57,000 for the Fiscal Years 2023 - 2025.
This includes $500 in expenses and $56,500 in DoD labor.
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Table of Contents

List of Figures

1. Executive Summary

This report discusses efforts to incorporate innovative materials and advanced construction techniques into criteria and specifications (i.e., Unified Facilities Criteria (UFC) and Unified Facilities Guide Specifications (UFGS)) used in military construction projects. This includes the use of materials that contain increasing amount of sustainability properties that meet the requirements of laws, regulations, policies, and industry standards. The report also discusses efforts to integrate innovative building materials into its designs, current examples of this in sustainable materials pilot projects, Research and Development (R&D), and resources needed to accomplish these efforts.

2. Congressional Reporting Requirements

DIVISION J - MILITARY CONSTRUCTION, VETERANS AFFAIRS, AND RELATED AGENCIES APPROPRIATIONS ACT, 2023 JOINT EXPLANATORY STATEMENT

"Integration of Innovative Construction Materials. The Committees are aware of new and innovative building materials that are becoming more prevalent within the construction industry. The Committees are concerned that DOD continues to rely on traditional building materials, using standardized designs across the Department based on those same traditional materials and that the Unified Facilities Criteria (UFC) and Unified Facilities Guide Specifications (UFGS) are not up to date with innovative and sustainable assets. Therefore, the agreement directs the Assistant Secretary of Defense for Energy, Installations, and Environment to provide a report to the Committees within 180 days of enactment of this Act on its efforts to incorporate sustainable products into the UFC and UFGS, integrate sustainable building materials into its designs, and any resources needed to accomplish these efforts."

3. Introduction and Background

The DoD remains a leader in the Federal Government with a significant stake in the Federal buildings sector as, by far, the largest owner and operator of buildings and other infrastructure assets in the world. To support the Department's mission, it has long supported the integration of innovative materials into building solutions to meet special durability requirements in marine construction, life extension requirements in pavements, force protection requirements in hardened structures, and sustainability-centric requirements to preserve the capacity to continue the mission without compromise. Any new material that meets existing performance requirements is inherently compliant with the UFC. New techniques, materials, or product types that prompt the DoD to revise performance requirements generally need to be well vetted, have sufficient engineering guidance, be specifiable (i.e., describable through performance or prescriptive requirements), available at the scale to be used widely in construction, and available without requiring sole source procurement. The development and integration of material technologies have long followed the same path:

1. Technology developed through DoD R&D programs (e.g., research, development, testing, and evaluation programs or other resources) or by leveraging technologies from other government, industry, and academic partners.

2. Demonstrations and pilot projects to prove out feasibility of the material at prototype / project scale and develop the pertinent designs, specifications, and overall project delivery requirements to support future use.

3. Integration into criteria and specifications along with influencing referenced building codes and standards which apply to military construction projects.

Technology, particularly in the field of materials and manufacturing, is always advancing and it is the goal of our R&D community to stay abreast of these advancements and to identify, develop, and integrate high impact material technologies into the DoD's construction portfolio. Criteria experts and designers carefully consider this integration of new ideas based on the technology readiness level of the materials and products; applicability to the mission; and ability to meet Federal Acquisition Regulation (FAR) competition requirements. While many materials developed in academia, industry, and government labs can provide unique performance such as improvements in strength, durability, or lower environmental and human health impacts; they must be demonstrated at scale, have the appropriate codes and tools for design, and must have a supply chain sufficient to support the large needs of construction projects. Only then, would a material be valid for consideration to be included the criteria and specifications that govern all military construction projects – those being the UFC and UFGS.

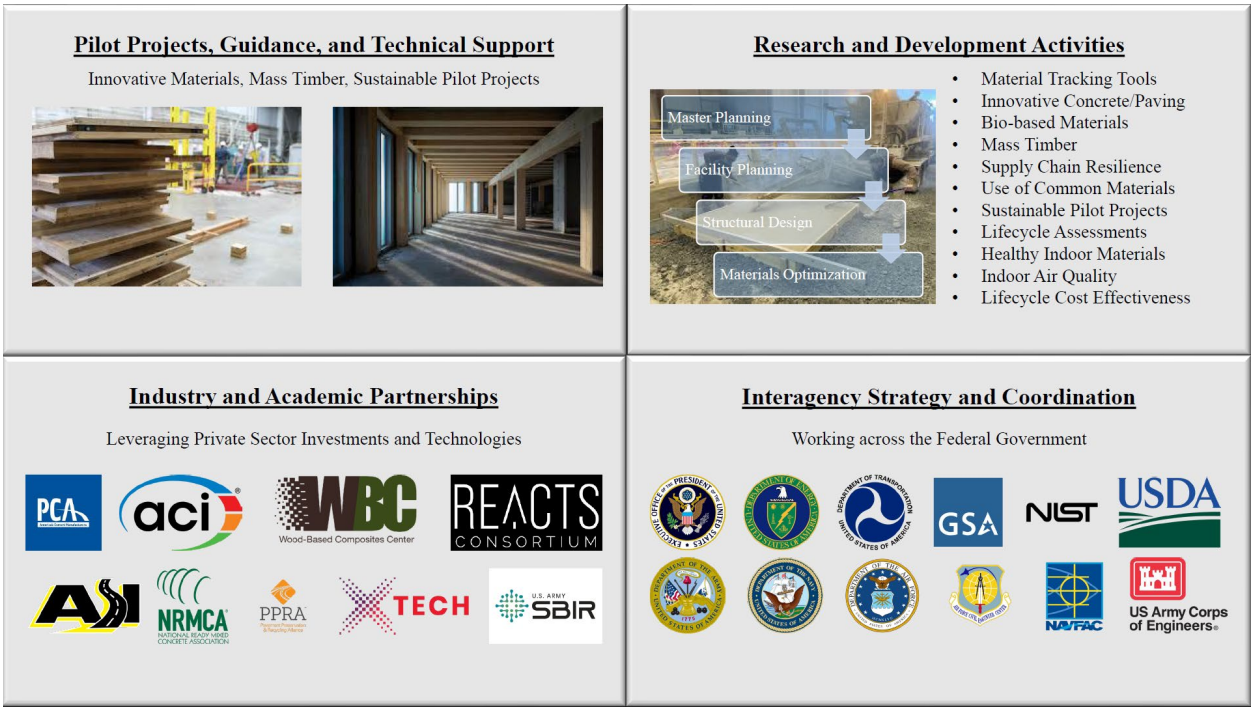
In support of many administration and congressional priorities in sustainability over the past five decades, the DoD and its military construction program; through the U.S. Army Corps of Engineers (USACE), Air Force Civil Engineer Center (AFCEC), and Naval Facilities Engineering Systems Command (NAVFAC), have long focused on sustainability by including requirements in criteria like UFC 1-200-02 *High Performance and Sustainable Building Requirements*, as well as incorporating minimum thresholds for sustainability into applicable UFGS (500+). These criteria have historically focused on the ability to operate into the future without decline – either in the mission or in the natural and man-made systems that support it.

Sustainability objectives are often aligned with durability objectives in ensuring long service lives in buildings and infrastructure projects. Examples of this include corrosion mitigation in marine concrete through low permeability concrete and corrosion resistant reinforcement or coating systems for asphalt pavements that protect it from the environment and extend its functional service life. These examples demonstrate an increased lifespan of assets leading to reduced total cost of ownership.

Today, with innovative and cost-efficient materials front and center, the DoD is moving forward through multiple efforts including near-term adaptation of criteria and specifications, pilot projects to demonstrate building materials with sustainability properties beyond industry and criteria standards, R&D, and pervasive partnerships across government, industry, and academia as illustrated in Figure 1 below.

Figure 1: Innovative Materials

Innovative materials focused initiatives including near-term pilot projects, guidance modernization, and technical support; mid- and long-term R&D activities; and partnerships across government, industry, and academia.



Ultimately, the goal of these activities is to rapidly advance criteria and specifications to focus on cutting-edge sustainability (materials and assessment metrics), conduct R&D to address remaining knowledge gaps such as force protection design and lifecycle durability, and to leverage as much as possible other investments to focus DoD resources on the highest impact problem sets.

The ideal outcome of these efforts is to integrate the most effective and innovative technologies into the DoD's UFC and UFGS documentation to support broad use across military construction projects. The following sections describe the programs that modernize our criteria and specifications and means of integrating innovative technology from industry; current pilot projects in the military construction portfolio focused on sustainable building materials; and various R&D efforts.

4. Standards and Criteria

The Standards and Criteria program is the primary executer of all criteria and specifications used across the DoD military construction portfolio and manages modernization of these documents. The goal of the program is to furnish state of the art criteria and specifications for life cycle cost effective DoD military construction projects that leverage other building codes,

specifications, and standards to the maximum extent possible with additional requirements that are unique to DoD projects.

A common misconception is that the UFC must explicitly permit a technology. The reality is that any innovative technology or material that meets the existing criteria can be used. The intent of the UFC is to champion innovation by establishing performance-based requirements that can be met through a myriad of materials, means, and methods. In general, they do not prescribe a solution, but to provide the performance criteria to which the solution must abide. UFC 1-200-01, General Building Requirements, addresses this topic directly with a clause in paragraph 2-1.4 to dispel the misconception:

> ***104.11 Alternative materials, design and methods of construction and equipment***
> *The provisions of this code, UFC, or FC are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design, or method of construction may be approved where the Building Official/AHJ finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, UFC, or FC, and that the material, method, or work offered is, for the purpose intended, not less than the equivalent of that prescribed in this code, UFC, or FC in quality, strength, effectiveness, fire resistance, durability, and safety. When the alternative material, design, or method of construction is not approved, the Building Official/AHJ will respond in writing, stating the reasons why the alternative was not approved.*

There are approximately 700 UFGS, divided into forty-eight MasterFormat divisions. MasterFormat is the industry standard for construction specifications. MIL-STD-3007G *DoD Standard Practice UFC, FC, and UFGS*[1] is the DoD standard that establishes policy for developing and maintaining UFC and UFGS. These standards serve as common facility guidelines and engineering practices for the DoD and other supported agencies. Key points about MIL-STD-3007G:

1. **Purpose:** The standard aims to provide consistent criteria for facility planning, design, construction, operation, maintenance, sustainment, restoration, and modernization of facilities owned by the DoD.

2. **Applicability**: UFC and UFGS apply to various aspects of facility management.

3. **Development and Maintenance**: The procedures outlined direct the development and ongoing maintenance of these unified criteria and specifications.

4. **DoD Consensus Standards:** The Military Departments collaboratively develop UFC and UFGS in accordance with their authorities under Title 10, United States Code. As a result, these standards represent a consensus within the DoD community.

For more detailed information, please refer to the full MIL-STD-3007G document.

[1] https://www.wbdg.org/FFC/FEDMIL/milstd3007g.pdf

Agencies incorporate UFCs and UFGS in all design and construction projects as detailed in their regulations and policies listed below for each Military Department.

The Department of the Army uses the following established processes and procedures for project execution:

- Engineer Regulation (ER) 1110-3-12 *Quality Management*: This regulation focuses on quality management in military engineering and design. It provides policy, guidance, principles, practices, and tools for delivering quality products and services to stakeholders of the USACE.
- ER 1180-1-6 *Construction Quality Management*: This regulation specifically addresses quality management in construction projects. It outlines procedures and practices related to ensuring the quality of construction work.
- ER 5-1-11 *USACE Business Process*: While not directly related to project execution, this regulation establishes policy and doctrine for all work performed by the U.S. Army. It provides guidance on business processes within the USACE.

The Department of the Navy uses the following established processes and procedures for project execution:

- NAVFAC Instruction (NAVFACINST) 3960.1 *Technical Oversight and Acceptance Testing of Critical Systems:* Instruction provides processes and business rules for the quality assurance of critical systems.
- NAVFAC Instruction (NAVFACINST) 11000.1 *Design Engineering Competency:* Ensures NAVFAC designers develop and maintain technical expertise required for agility, efficiency, and cost effectiveness to expertly deliver design and construction projects to our Supported Commanders. Instruction provides business rules.
- NAVFAC Instruction (NAVFACINST) 11010.44 *Short Facilities Planning Manual* Series outlines quality control procedures for construction projects within the Navy.
- NAVFACINST 11010.44 Series also covers construction quality management aspects, ensuring that Navy construction projects meet established standards.
- NAVFACINST 11010.44 Series and other related instructions provide guidance on standardization and consistency in Navy facilities.
- NAVFAC Instruction (NAVFACINST) 11012.1A *Design Execution:* Provides approach to projecting, staffing, inducting & executing design products and services at the appropriate offices to best deliver military construction projects. Instruction provides guidelines & framework. NAVFAC *Designer Handbook (P-404):* Explains the roles and responsibilities of the NAVFAC Designers throughout the various phases of the project's life. This handbook is intended to be used as a reference for designers or anyone else interested in learning more about NAVFAC design processes and the role of the designer.
- NAVFAC Planning, Design, and Construction Directorate (PDC) *Project Management Manual (P-407):* Provides guidance for managing projects within the NAVFAC portfolio of work.
- NAVFAC *Construction Management Handbook (P-405):* Explains the roles and responsibilities of the NAVFAC Construction Engineer (CE) and Construction Manager

(CM) and includes the Construction Management Personnel Qualification Standards (CMQS) process with procedure for obtaining a NAVFAC Qualified Construction Manager Certificate,

- NAVFAC Instruction (NAVFACINST) 4200.1 *Contracting Officer's Representative*: Provides authority from the Contracting Officer to the Contracting Officer's Representatives to help make crucial technical decisions and enforce contract requirements.
- Department of the Navy Instruction (SECNAV INSTRUCTION) 5400.15D *Department of the Navy Research and Development, Acquisition, Associated Life-Cycle Management, and Sustainment Responsibilities and Accountability:* Describe the duties and responsibilities of, and relationships among, the Assistant Secretary of the Navy for Research, Development & Acquisition (ASN (RD&A)) and the Program Executive Officers (PEOs) and Direct Reporting Program Managers (DRPMs), the Chief of Naval Operations (CNO), the Commandant of the Marine Corps (CMC), the Commanders of the Systems Commands (SYSCOMs), and the Chief of Naval Research (CNR) for research and development, acquisition, and associated life-cycle management and sustainment.

The Department of the Air Force uses the following established processes and procedures for project execution:

- Air Force Instruction (AFI) 32-1023 *Designing and Constructing Military Construction Projects*: This AFI outlines general design criteria, standards, and procedures for Air Force military construction projects.
- AFI 32-1021 *Planning and Programming MILCON Projects*: This AFI focuses on planning, developing, and obtaining approval for military construction projects.
- United States Air Force Project Managers' Guide for Design and Construction

Military Departments may also choose to provide specific guidance or requirements related to their execution of military construction projects. Recent examples of this around innovative building materials include:

- USACE's issuance of Engineering and Construction Bulletin (ECB) 2023-14 *Mandatory Consideration of Mass Timber in Army MILCON and Civil Works Vertical Construction Projects*. While UFGS documents previously existed for glue laminated and cross laminated timber, they were seldom used, and mass timber was not emphasized or often considered as a material choice for military construction projects. The ECB was issued to provide a command driver for consideration of mass timber; along with concrete and steel, as a primary building material and to begin to shift procedures toward integrating these materials.
- NAVFAC issuance of Interim Technical Guidance (ITG) 2023-01 Aircraft Maintenance Hangar Optimal Structural System Evaluation. While UFCs currently allow for alternative construction methods to include tension fabric structures, pre-engineered metal buildings and other modular construction systems, they are not frequently utilized for construction projects, to include aircraft hangars. This ITG requires specific

consideration of new structural systems for all aircraft hangars and is being expanded to other facility types.

Furthermore, the addition of novel construction technologies in the UFC with the incorporation of innovative and resilient materials allows for the implementation of more efficient construction practices. One example is the UFC language published on additively constructed concrete (UFC 3-301-01 Section 2-7.2).

5. Criteria Change Requests

The Criteria Change Request (CCR) process is an established process for formerly suggesting or recommendations specific changes to improve the criteria documents. Although industry representatives often reach directly to project managers or engineers to market innovative technologies, the CCR process is the only official means of cataloging and prioritizing requests for modifications to criteria and specifications generated by government, industry, or academic personnel. CCRs are the critical backbone and communication avenue to industry and manufacturers. Industry can submit a CCR on any UFC, UFGS, and FC through the open Whole Building Design Guide (WBDG.org) website. The CCR process is established by Mil-STD-3007G. Highlights from MIL-STD-3007G below:

"3.11 Criteria change request (CCR). A criteria change request, commonly referred to as a CCR, is a requested change or revision to the criteria. CCRs may be provided by anyone, such as but not limited to industry, private entities, or DoD personnel. CCRs are submitted electronically via links provided on the WBDG and automatically routed for adjudication to the appropriate criteria managers within Discipline Working Groups (DWGs) or Functional Working Groups (FWGs)."

"5.1.15 Feedback. User comments and recommended changes to UFC or FC, with rationale for the changes, shall be sent electronically using the CCR link next to the electronic version of the document."

"5.5.1 CCR resolution. It is the responsibility of the technical proponent to review the comments and recommended revisions and changes, determine if it merits research and incorporation, and estimate the effort required to incorporate the change."

In practice, CCRs include a multitude of different topics – many focus on materials. The CCR process prompts contributors for specific language that should be revised, ensuring industry can help shape the language precisely and accurately. CCRs are processed during periodic updates to criteria and specifications by pertinent discipline working groups.

Recent examples in the field of innovative and sustainable materials include updates in the marine concrete guide specifications to include new types of cement, supplementary cementitious materials, high strength reinforcing bars, novel waterproofing membrane technologies, and various corrosion resistant stainless steel and composite materials. Currently, experts are evaluating CCRs on cement and concrete materials to include adaptation of fly ash

requirements for supplementary cementitious materials, maximum strength requirements to mitigate overdesign, promotion of blended and performance-based cements that are more sustainable, and allowance of alternative cementitious materials from recycled sources. Another example is the broad resilience-centric updates to UFC and UFGS documents. These planned updates include data collection to track and understand human health and environmental impacts over the lifecycle of a project; adapting allowable materials and standards to promote resilience; and adjusting prescriptive and performance requirements for those materials to ensure both sustainability and lifecycle performance objectives can be met.

6. Pilot Projects

Large scale technology demonstrations, prototyping, and pilot projects are critical to understanding how to design and specify with innovative materials. The DoD executes demonstrations and pilot projects through a range of different programs from research, development, test, and evaluation (RDT&E) funded activities to demonstrations under the Environmental Security Technology Certification Program, the Installation Technology Transition Program, and the DoD Corrosion Prevention and Control program, among others. The DoD is currently executing a series of pilot projects with a specific focus on sustainable building materials with low lifecycle impacts. The activities include:

- Section 2861 of the FY 2022 NDAA directed mass timber and low carbon concrete materials pilot projects across the Army, Air Force, and Navy. A summary of these projects which are well underway is provided in the following section.
- Mass Timber pilot projects underway by the Army and Air Force.
- Net Zero pilot projects directed by the Office of the Secretary of Defense to focus on resilient materials, passive design, and energy aspects. These projects are also planned to be executed via Other Transaction Authority (i.e., non-FAR based) procurements.
- Various service-specific pilot projects to explore innovative building techniques such as additive construction, off-site construction, and tension fabric structures.

Section 2861 of the FY 2022 NDAA, as modified by Section of 2871 of the FY 2024 NDAA , mandated DoD to establish a pilot program for sustainable materials, including mass timber and innovative concrete, in military construction and to prioritize resilience factors. It mandated the inclusion of at least one barracks or unaccompanied military personnel housing complex. The Army, Navy, and Air Force each selected two projects. The execution of the pilots has already led to multiple specification updates and modifications to facilitate integration of sustainable strategies. Each of the projects is being supported by the U.S. Army Engineer Research and Development Center (ERDC), the R&D organization of the USACE, to provide technical support and analysis through the delivery of the three projects.

The general scope of the pilot programs focuses on maximizing the potential use of innovative and sustainable building materials (balanced by cost, schedule, and lifecycle performance factors), to update design and specifications to account for these materials, to track their implementation in construction, and to conduct analysis of lifecycle sustainability as well as cost and schedule impacts on the selected projects. In tandem with execution of the pilot

projects, the Standards and Criteria program has been heavily integrated and tracking activities with the goal of rapidly integrating successful outcomes of the projects into updated UFC and UFGS documents that directly leverage specific language developed for the projects and any lessons learned. The three pilot projects are as follows:

Army Project: Barracks Complex at Joint-Base Lewis McCord (JBLM) in Washington

The Department of the Army selected the fiscal year 2024 Army military construction project for an Unaccompanied Enlisted Personnel Housing (UEPH) project at JBLM. The pilot project will construct an 89,082 sf UEPH for 168 soldiers. It will focus on the use of sustainable building materials, specifically reducing the total environmental impact by incorporating innovative material substitutions.

A total of nine UFGS were modified (multiple times each, especially in the case of UFGS 03 30 00 *Cast-In-Place Concrete*) to be sustainability-centric with a focus on prescriptive and performance requirements to reduce impacts and focus procurement on regionally available materials. One of the key modifications includes the adoption of Portland limestone cements in concrete, using binary and ternary blends with significant replacement of Portland cement with supplementary cementitious materials, and limiting total cement contents. Unlike previous projects where it was merely an option, this pilot requires its usage to enhance sustainability. In total, the updates covered one specification for structural concrete, four specifications for structural steel, roofing materials, and other building façade systems, one modification in design related to brick façade, and three specifications for insulation materials. Specifications for the final design were updated to consider the most sustainable alternatives to conventional materials including concrete, steel, and materials in the building envelope such as insulation. The project was awarded in April 2024 at 67 percent of the $100M Programmed Amount. Construction is set to be completed in 2027. The insights gained from this pilot project will influence future military construction projects, including the upcoming fiscal 2025 JBLM Mass Timber Barracks project, potentially leading to further cost reductions and efficiency improvements across the Army's infrastructure.

Navy Project: Child Development Center (CDC) at Hampton Roads in Virginia

The Department of the Navy selected the FY 2024 P1334 CDC that will be located at Naval Support Activity Hampton Roads, Norfolk, Virginia. This childcare/development facility will be approximately 40,000 sf and handicapped accessible to serve three hundred infants, toddlers, and pre-school aged children of military and civilian personnel. The proposed structural system is a concrete slab on grade, with proposed hybrid concrete and steel members or glue-laminate and cross laminated timber members as the primary structural building members.

The requirements have been developed based on planning factors, standards, and guides prescribed by the UFC-2-000-05N *Facility Planning Criteria for Navy/Marine Corps Shore Installations* for category code 74074 (Child Development Center) and an engineering analysis. Based on the initial identification of mass timber as the primary structural building material, force protection criteria were considered, and analysis is currently underway by the Army ERDC

with support from the USACE Protective Design Center. This project is currently moving toward final design and finalizing its consideration of mass timber usage throughout the project.

Air Force Project: Consolidated Communications Complex (CCC) at Patrick Space Force Base (PSFB) in Florida

The Department of the Air Force has selected the CCC at PSFB, Florida as its pilot project. The CCC project is 91,000 sf, three-story Space Communications facility with a Joint Operations Center and Command Post. The facility will be designed as permanent construction in accordance with UFC 1-200-01 *DoD Building Code* requirements. This project will comply with DoD Antiterrorism/Force Protection requirements per UFC 4-010-01 *Minimum Antiterrorism Standards for Buildings*.

Coordination between the project development team and Army Engineer Research and Deployment Center personnel resulted in four UFGS updates to Section 03 30 00 *Cast-in-Place Concrete* meant to promote reduction of the environmental impacts of the concrete used on this project, including a subsection to set maximum allowable impacts in alignment with guidance from the General Services Administration, New Buildings Institute, and industry experts. Also, a subsection will be added requiring the material manufacturers provide documentation for each mixture used for the project. These documents outline the embodied energy, water, and impacts of the material and are necessary for understanding the value of innovative materials. Verbiage was added to the subsection for blended cements providing options for the contractor to use blends allowed in the 2014 edition of American Concrete Institute's (ACI) 318-14 *Building code Requirements for Structural Concrete* and a separate subsection related to each of the permitted supplementary cementitious materials will include larger allowable substitution percentages within the scope of ACI 318-14, providing more room for contractors to reduce the cement content of mixtures.

These adjustments are in alignment with guidance from the National Ready Mix Concrete Association for sustainability focused concrete. The proposed modifications to the specifications will have no negative impact on the strength of concrete or the design that has been conducted for the CCC project. These modifications are anticipated to result in a 30-40 percent reduction in the environmental impacts for concrete used in the CCC project when compared with conventional concrete baselines. The target reduction also represents a 20 percent improvement over sustainability goals provided by the National Building Institute for sustainable building materials in the five thousand pounds per square inch strength range.

This project is also at 100 percent design and awaiting final approvals on secure facility configuration adjustments and appropriations to move forward with contracting.

7. Research and Development

Development, demonstration, and transition of innovative materials has historically been the subject of R&D. USACE (through ERDC), AFCEC, and NAVFAC each execute R&D in construction materials for vertical and horizontal construction ranging from buildings to bridges

and airfields. One large gap in this field is the lack of Applied Research and Advanced Technology Development RDT&E resources to support innovations in materials for construction. These investments have been focused, in the engineer mission, on contingency construction applications rather than enduring facilities. Advanced Component Development and Prototypes RDT&E resources have been available and often aligned with energy and environmental topics of research. In 2023 because of Office of the Director of Cost Assessment and Program Evaluation activities to support climate mitigation and adaptation requirements and other service-directed requirements, new R&D programs were initiated around sustainable building materials. Many of these activities are being executed by the ERDC in support of both the Army through the Assistant Secretary of the Army (Installations, Energy and Environment) and AFCEC (focused on airfield pavements).

Considering that approximately 20 percent of the anticipated building portfolio for the year 2045 is yet to be constructed, it is imperative that innovative and sustainable materials parameters be researched and integrated into guidance protocols quickly. The main outcome of these R&D activities will be the development of CCRs and coordination with the Standards and Criteria program to make innovation and sustainability focused updates to UFC and UFGS documents. Through meticulous evaluations and updates to more than fifty specifications concerning asphalt, concrete, geosynthetics, timber, and biomaterials, DoD has demonstrated an ongoing commitment to using innovative materials to sustainably address near- and medium-term construction challenges.

Three near-term updates have already been submitted as CCRs in FY 2024. The first allowing the use of a tried-and-true supplementary cementitious material called silica fume to offset up to five percent of cement in each concrete blend. This renders an increase in strength, decrease in cost, and decrease in total cement usage which in turn decreases project emissions. The second allows the use of "triple-blended" ternary cements to increase concrete strength while reducing cost and environmental impacts. The CCR overrides the historical precedent (which only allowing unary and binary blends), since ternary cements are now commonly employed in industry. The third CCR corrects a labeling error that may have impeded the use of pozzolanic materials to improve sustainability in concrete assets. Other efforts to allow alternative cementitious materials, recycled materials such as waste glass, and to promote performance-based cements that can be manufactured with innovative feedstocks are also underway.

Example medium-term research efforts include quantification of life-cycle parameters related to the carbonation process in concrete, where the material reabsorbs carbon dioxide emitted during the manufacturing process gradually. This research will provide an "offset" metric used to determine the true emissions associated with the life-cycle environmental impact of these materials relevant to UFGS 01 33 29 *Sustainability Requirements and Reporting*. Research studies have estimated that this lifecycle process may be able to offset up to 20 percent of the initial emissions of the concrete. Additionally, research to evaluate the geographical heterogeneity of Type IL cement develop performance indicators of this more sustainable cement product to balance sustainability goals with performance metrics relevant to UFGS 03 30 00 *Cast-in-Place Concrete* among other concrete specs (UFGS 32 16 19, UFGS 03 30 53, etc.).

Research in asphalt sustainability is targeting new methods and materials for extending pavement life. Materials include rubber-modified asphalt, recycled asphalt pavement, and cold in-place recycled asphalt. Research supports updates to UFGS 32 12 16.16 *Road-Mix Asphalt Paving* and others. Additional research with Redstone Arsenal Airfield on novel surface treatments will elucidate the extension of service life achievable with novel coatings and support updates to UFGS 32 12 15.13 *Asphalt Paving for Airfields*.

In the realm of timber and bio-based materials, research to test and demonstrate cutting-edge bio-adhesives and cross-laminated timber (CLT) strategies were conducted to inform specification updates to UFGS 06 17 19 *Cross-Laminated Timber*. The aim is to inform and enhance CLT specifications and evaluate the opportunity to combine CLT panels with bio-based insulation, creating structural insulated panels for thermal and mechanical demonstrations. This novel approach could revolutionize energy-efficient construction techniques, improving the total sustainability associated with new buildings and infrastructure. In addition, novel bio-based soil stabilization technologies are being actively researched to evaluate their performance in relevant environments. These materials are being characterized through laboratory experiments to define the chemical reactions as a necessary step in developing guidance for field applications. Once characterized, these innovative bio-based soil stabilizers are being evaluated through full-scale field demonstrations that provide valuable insights into the logistical requirements and construction methods that are most effective. These results are being synthesized for updates to UFC 3-250-11 Soil Stabilization and Modification for Pavements.

Geosynthetics are man-made polymeric products that are manufactured to solve geotechnical problems in construction projects. Geosynthetic materials provide innovative solutions to many infrastructure applications including separation, drainage, reinforcement, and containment. The inclusion of the geosynthetics often provides a more efficient solution than traditional construction techniques. Research projects have been conducted to quantify the performance enhancement associated with the several types of geosynthetic materials including geotextiles, geogrids, geocells, and geocomposites. Recent studies have demonstrated significant performance improvement characteristics that allow reductions in the number of traditional materials required or the use of marginal materials of lower quality to perform the same function. Currently, research projects are underway to improve the Government's understanding of which material properties impact performance with the goal to inform the update of UFC 3-220-08 and the development of new UFGSs for innovative geosynthetic applications in infrastructure construction.

The materials addressed in future specification updates are being funded via Assistant Secretary of the Army (Acquisition, Logistics, and Technology) through the Army Applied Small Business Innovation Research program. In late FY 2023, the Army awarded sixteen small businesses with promising technologies $12.25 million funding. Federal researchers are managing these efforts to streamline the development and integration of additional innovative and sustainable building materials into the federal marketplace. In tandem with these internal and external DoD research efforts, DoD has been collaborating extensively across the Federal Government; most notably with the General Services Administration, Department of Energy, Environmental Protection Agency, Department of Commerce and its National Institute of Standards and Technology, and the U.S. Department of Agriculture related to forest products.

8. Summary

The DoD is working to incorporate innovative construction materials across the military construction portfolio through modernization of criteria and specifications, pilot projects to vet innovative and sustainable material technologies, and investments in R&D. As discussed, the goal of all these activities is to integrate feasible and effective materials into the DoDs criteria and specifications. Since the criteria program can only require, as an enterprise standard, the minimum allowances that can be supported by a preponderance of industry manufacturers, opportunity exists for each sector of the industry with DoD and the rest of the public sector to establish common standards for the adoption of innovative materials.

Appendix A – List of Acronyms

AFCEC – Air Force Civil Engineer Center
AFI – Air Force Instruction
CCC – Consolidated Communications Complex
CCR – criteria change request
CLT – cross-laminated timber
DFARS – Defense Federal Acquisition Regulation
DWG – discipline working group
ECB – Engineering and Construction Bulletin
ER – Engineer Regulation
ERDC – Engineer Research and Development Center
FAR – Federal Acquisition Regulations
FC – Facilities Criteria
FWG – functional working group
FY – fiscal year
ITG – Interim Technical Guidance
JBLM – Joint-Base Lewis McCord
LCA – life cycle assessment
NAVFAC – Naval Facilities Engineering Systems Command
NAVFACINST – NAVFAC Instruction
PSFB – Patrick Space Force Base
R&D – Research and Development
RDT&E – Research, Development, Test, and Evaluation
UEPH – Unaccompanied Enlisted Personnel Housing
UFC – Unified Facilities Criteria
UFGS – Unified Facilities Guide Specifications
USACE – U.S. Army Corps of Engineers
WBDG – Whole Building Design Guide