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Inclusion of Sustainable Materials and Innovative Techniques in Military Construction

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Abstract

The Department of Defense faces challenges in incorporating sustainable materials and innovative construction techniques into military construction (MILCON) projects. As such, the National Defense Authorization Act, Section 2851, required the Secretary of Defense to commission a study to evaluate current practices affecting the inclusion of sustainable materials, as well as to examine barriers to incorporating innovative construction techniques and determine whether the Strategic Environmental Research and Development Program or the Environmental Security Technology Certification Program could be used to validate sustainable materials and innovative techniques. In response, the Deputy Assistant Secretary of Defense for Infrastructure Modernization and Resilience asked CNA to conduct the present study. We examined various data sources, including Unified Facilities Criteria and Criteria Change Requests, and interviewed US government subject matter experts to identify potential barriers to including sustainable materials and innovative techniques in MILCON. We identified several barriers, including a broad lack of relevant knowledge, availability of sustainable material data, and forcing functions.

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INTRODUCTION

This study responds to the Fiscal Year 2023 National Defense Authorization Act (NDAA), Section 2851, directing the Secretary of Defense to commission a study on the practices of the Department of Defense (DOD) with respect to the development of military construction (MilCon) projects and submit the results of the study to congressional defense committees. This study represents relevant background information and the significant findings of a much larger body of work also commissioned (and also conducted by CNA) in response to Section 2851 titled *Inclusion of Sustainable Materials and Innovative Techniques in Military Construction*.¹

Specifically, Section 2851 requires an examination of the following:

1. Practices with respect to adoption of Unified Facilities Criteria (UFC) changes and the inclusion of such changes into advance planning, Defense Department (DD) Form 1391 documentation, and planning and design.²
2. Practices with respect to how sustainable materials, such as mass timber and low-carbon concrete, are assessed and included in advance planning, DD Form 1391 documentation, and planning and design.

¹ Brent Richardson, Michelle LaDuca, William Komiss, and Randall Gentry, *Inclusion of Sustainable Materials and Innovative Techniques in Military Construction*, CNA, DRM-2024-U-038639-Final, 2024.

² The term *advanced planning* was used in the original NDAA required study tasking and is defined only in DOD FMR 7000.14-R, Volume 3, Chapter 17, Appendix A. The definition as described in the FMR is not consistent with DOD definitions. Apparently, *advanced planning* was used to reference activities that occur prior to design. The term was changed to *advance planning*, which describes such activities and is defined in the Office of the Assistant Secretary of Defense for Energy, Installations, and Environment (OASD (EI&E)) memorandum "Guidance for Military Construction Planning and Design," June 2023.

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3. Barriers to incorporating innovative techniques, including 3D-printed building techniques.
4. Whether the Strategic Environmental Research and Development Program (SERDP) or the Environmental Security Technology Certification Program (ESTCP) could be used to validate such sustainable materials and innovative techniques to encourage their use by the US Army Corps of Engineers (USACE) and the Naval Facilities Engineering Systems Command (NAVFAC).

The use of sustainable materials and innovative construction techniques in MilCon can decrease DOD greenhouse gas emissions and is crucial to meeting an array of goals related to net-zero energy, emissions, water, and waste. DOD policies encourage the use of sustainable materials and innovative techniques in MilCon, and DOD component labs are actively testing and evaluating sustainable materials and innovative techniques. However, several barriers prohibit more widespread use of sustainable materials and innovative techniques in MilCon. This report discusses those barriers and ongoing efforts to further expand the inclusion of sustainable materials and innovative techniques into MilCon.



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BACKGROUND

Planning and design in MilCon

The MilCon program “enables the DOD to plan, program, design, and build infrastructure,” and it follows a “lengthy” process governed by multiple planning, design, and funding guidance documents.³

With respect to a MilCon project, advance planning (or just *planning*, as the terms are synonymous) activities occur before a service component requirement develops into a MilCon project. These activities are listed in a 2023 Office of the Assistant Secretary of Defense for Energy, Installations, and Environment (OASD (EI&E)) memorandum, “Guidance for Military Construction Planning and Design.”⁴ The project planning process begins with initial project requirement identification, and planning activities can include documenting and developing DOD stakeholder requirements, developing an installation master plan, conducting alternative site studies, and preparing environmental impact assessments and statements.⁵ The respective military department (typically the uniformed installation commander) then validates the project requirement and priority and determines that the project requires MilCon appropriations, after which the installation will develop and detail the planned cost and scope on the initial DD Form 1391.

The service component approval of the DD Form 1391 and congressional notification of the start of design typically mark the transition from the *planning* phase to the *design* phase. MilCon design activities are performed in predetermined phases, and the



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number of phases and level of detail required for each phase depend on the complexity of the project.⁶ The 35 percent design stage is a critical milestone because the team must provide sufficient detail to define scope, design criteria (including identification of required UFC documents), and cost estimates.

Unified Facilities Criteria

The UFC program is overseen by the DOD Engineer Senior Executive Panel (ESEP), which is made up of the Deputy Assistant Secretary of Defense for Infrastructure Modernization and Resilience, the Army Corps of Engineers Chief of Engineering and

³ Congressional Research Service, *Military Construction: Authorities and Processes*, Apr. 28, 2023, <https://sgp.fas.org/crs/natsec/R44710.pdf>.

⁴ OASD (EI&E), “Guidance for Military Construction Planning and Design,” June 2023.

⁵ Individual projects are required to be consistent with installation-level master plans. Master plans are a requirement for all military installations, as outlined in DODI 4165.70 and guided by UFC 2-100-01. The master plan will describe the long-range strategy for installation development. Real Property Master Plans and Installation Development Plans—a subset of “master plan”—will address land use and may address utility systems and parking.

⁶ DOD FMR 7000.14-R, Volume 3, Chapter 17.

Construction, the Naval Facilities Engineering Systems Command Chief Engineer, and the Director of the Air Force Facilities Engineering Directorate. Under this leadership, the UFC program provides planning, design, construction, sustainment, restoration, and modernization criteria for all construction projects. UFC and Unified Facility Guide Specifications (UFGS) documents (collectively referred to herein as “UFC documents”) include planning guidelines, design criteria, and specifications for material and product performance. One of these documents—UFC 1-200-02, *High Performance and Sustainable Building (HPSB) Requirements*—includes the minimum requirements for the use of sustainable products, and many UFGSs contain minimum sustainability thresholds. In addition to statutory requirements for energy and water, requirements are included, for example, for enhanced indoor air quality via zero volatile organic compounds for interior materials and moisture control during construction; reduced impact of materials through environmentally preferable products and renewable and recycled content; limited ozone-depleting substances; waste diversion; reduction of embodied carbon through use of fly ash, slag, and low-carbon cement in concrete; option for use of mass timber; and forest management certification for all applicable wood products. Certain other UFC documents guide the development of the project’s planned cost and scope, which are stated on a project’s DD Form 1391.

UFCs and UFGSs are living documents. Their users help revise the documents when they find errors or identify places in the documents that have failed to keep up with technology, economics, and other factors. The primary audience for UFC documents is the MilCon design team. Although a few UFC documents provide planning requirements, most UFC documents outline engineering and design-scoping criteria.

Evaluation of sustainable materials and innovative techniques

Several DOD programs and labs are involved in evaluating sustainable materials and innovative techniques. SERDP and ESTCP serve DOD in the development, validation, and demonstration of technologies that address high-priority DOD environmental problems affecting mission readiness and environmental liabilities. They have had great success in validating technologies for use by DOD and can be further leveraged to validate identified sustainable materials and innovative techniques for MilCon.

An additional DOD resource that can be leveraged to validate materials and technology is the DOD Sustainable Technology Evaluation and Demonstration (STED) program, funded through ESTCP. The STED program evaluates, demonstrates,



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and transitions sustainable technologies and products that are commercially available and align with DOD and federal agency mission requirements. The STED validation process includes identification of the “capability to cost” of products. It has successfully identified sustainable alternatives, validated technical data, and demonstrated technologies. Whereas SERDP and ESTCP may have dozens of funded projects ongoing at any time, the STED program conducts only four to six demonstrations annually.

USACE’s Engineer Research and Development Center (ERDC) and NAVFAC’s Expeditionary Warfare Center (EXWC) are DOD component labs that maintain the authority and capability to assess and validate the use of sustainable materials and innovative construction techniques for use in MilCon. However, it should be noted that sustainable materials and innovative construction techniques are not the labs’ sole areas of focus. Although both labs have established relationships with ESTCP and SERDP

to support these efforts, ERDC and EXWC do not have formalized processes for selecting materials and techniques for research and evaluation, nor do the labs have the authority to update criteria and specification standards.

When a new material or technique is assessed, validated, or demonstrated by a DOD program or lab, the results of the study or research do not automatically affect UFC documents or MilCon decision-making. The study team will communicate results to the project sponsor, and if there is no project sponsor, the team may choose to share results with contacts from their service or organization. After receiving study results, project sponsors may opt to conduct further research, share the findings across DOD, promote the use of the material or technique, evaluate the product against existing UFC requirements, or initiate a Criteria Change Request (CCR) to update the UFC documents.

REQUIREMENT 1: Adoption of UFC Changes and Inclusion of Such Changes into MilCon Planning and Design

Background on the UFC change process

Changes to a UFC document may be initiated when any UFC user, such as a NAVFAC employee or construction contractor, submits a CCR, which is a notice of needed updates and recommended revisions. Users submit requests at the Whole Building Design Guide website, which is open to the public. Once a CCR has been submitted, the key entities responsible for its review are relevant DOD organizations whose employees' collateral duty assignments include the ESEP, the Coordinating Panel (CP), and the Discipline Working Groups (DWGs). Once the CCR is approved, it is adopted into the applicable UFC document.

Upon receipt of a CCR, the relevant DWG will review the content and suggestions and then make a recommendation to the CP. The DWGs do not evaluate whether specific materials or products meet minimum requirements set forth in the UFC documents. Rather, they evaluate industry standards regarding the various architecture and engineering disciplines established within the UFC program. As industry standards or other accepted evaluations for construction and design practices are updated, applicable DWGs determine whether and how to implement the updates into UFC documents, a process established in MIL-STD-3007G.

The CP reviews the recommendation from the DWG and submits its own recommendation to the ESEP, which has approval authority for UFC documents, including the authority to waive or exempt published

requirements that lie within its authority. All three entities consider factors such as the availability of nongovernmental and industry technical standards when determining the need to develop, revise, or change criteria. (For UFGS change requests, CP and ESEP approval are not required.)

Once approved, a CCR may be immediately adopted into the applicable UFC or adopted during a scheduled revision or change. An NDAA may also include direction to update UFCs. The DWGs will immediately begin to incorporate these required changes. The DWG does not use the CCR process for these changes.

Study findings

A review of approved and denied CCRs showed that there is a greater chance that a CCR will be approved in the following conditions:

- The submitter references missing standards.
- The submitter references conflicting guidance (e.g., two UFCs reference different versions of the same industry standard).
- Additional clarification of UFC document language is requested (e.g., requesting clear definitions of terms such as *slip resistance*).
- The submitter provides accurate and appropriate information, such as governing guidance required to update the UFC (e.g., the submitter provides the specific technical language to insert and the industry-recognized reference from which it comes).

A CCR is likely to be denied in the following conditions:

- The submitter does not reference governing documents applicable to the CCR.
- The submitter only mentions a potential problem with the UFC document instead of suggesting a change.
- The submitter does not include a governing industry standard with their CCR recommendation, even if the recommendation does not conflict with existing guidance.

The CCR system may not lead to automatic or speedy updates to UFCs, and several challenges can hamper the adoption of changes related to sustainable materials and innovative techniques:

- UFC change requests are not incorporated due to lack of knowledge regarding new materials and how they compare to performance specifications of more traditional materials.
- UFC change requests are not incorporated due to lack of knowledge of the life-cycle effects of new materials.
- UFC revisions can take weeks or many months to complete (available data did not reveal disparities for revision completion timeline differences among working groups).

REQUIREMENT 2: Assessment of Sustainable Materials and the Inclusion of Such Materials in MilCon Planning

Background on sustainable materials and requirements

The terms *sustainable material* and *sustainable products* are often used interchangeably, despite distinct differences. Although there is not a DOD definition of *sustainable materials*, such materials are occasionally referred to as “green materials” and can be broadly defined as materials derived from renewable resources, having low environmental impact for their extraction and production, and being more durable, with relatively long life cycles. Examples of sustainable materials that may be substituted for traditional construction materials include mass timber (a potential substitute for structural steel) and low-carbon concrete (a potential substitute for traditional concrete).

Sustainable products can be broadly described as products that are made with a *portion* of renewable or recycled resources (including sustainable materials) and require minimal production energy. Examples

of sustainable products include building insulation and nonpressure pipes containing postconsumer content. UFC 1-200-02, *High Performance and Sustainable Building (HPSB) Requirements*, includes the minimum requirements for the use of sustainable products in MilCon projects, as required by Executive Order 14057.

UFC documents permit a construction contractor to use any materials that meet the performance requirements in the contract specifications. There are more than 690 UFGS, many of which list minimum threshold requirements for sustainable materials and products such as UFGS 05 12 00, Structural Steel, which lists minimum recycled content for certain steel members. The contractor is required to formally submit material data to the construction agent who oversees the execution of the project. The construction agent reviews material submittals and accepts the material if it meets project design concept and contract documents.



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Study findings

Several barriers to increased thresholds of sustainable materials in MilCon projects were identified:

- Advance planning activities do not address material selection requirements. Selection of some sustainable materials for projects could result in cost overruns if the cost is not included in initial cost estimates. The iterative process of determining the sustainable materials usage continues until the final construction submittal is approved.
- The DOD MilCon team may lack knowledge of how to incorporate the use of additional sustainable materials into projects and may not know the regional availability of sustainable materials.⁷
- Lack of a cohesive strategy for developing and incorporating sustainable materials within the construction industry affects development of industry standards referenced in UFC documents (which influence MilCon planning and design efforts).
- Although some UFC documents require certain types of sustainable materials, there are no metrics to measure progress toward an increased usage of sustainable materials (nor are there common metrics used to measure quantities of sustainable materials used in MilCon projects).

The requirement for the inclusion of sustainable materials would not be identified until after the planning phase; it would take place in the design phase. For this reason, sustainable material requirements must be identified early in the design



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phase because construction material requirements may affect the overall cost of the MilCon project. In addition, MilCon design teams may lack the knowledge necessary to include sustainable materials in MilCon. For example, some sustainable materials are available only regionally, and it can be difficult to determine whether the material is available in the region in which the MilCon project is planned. In other instances, the team may be unaware of what sustainable materials exist.

Sufficient performance data required for the increased thresholds of certain sustainable materials may not be available due to a lack of industry standards to assess the performance data against. The lack of standards and data makes it challenging to assess whether the material is suitable for use in MilCon. This observation also highlights the

⁷ The DOD MilCon team consists of all those involved in the development of the project, including planners, engineers, architects, and contracting officers.

dependency of DOD on industry's investments in assessing sustainable materials. Finally, the lack of a requirement to incorporate sustainable materials into MilCon means that the design team has no incentive to incorporate the materials unless it is directed to do so at the installation level.

There are, however, efforts underway to increase inclusion of sustainable materials beyond the minimum thresholds in the UFGS templates in MilCon. For example, the USACE Chief of Engineering and Construction Division, Civil Works, released an Engineering and Construction Bulletin in September 2023 establishing a policy to consider the use of mass timber (e.g., cross-laminated timber and glue-laminated timber) when designing Army MilCon projects.⁸ The policy provides some basic implementation strategies as well as a list of design resources, including applicable UFC documents and recognized industry standards.

⁸ US Army Corps of Engineers/Chief of Engineering and Construction Division, Civil Works, Engineering and Construction Bulletin No. 2023-14, "Mandatory Consideration of Mass Timber in Army Military Construction (MILCON) and Civil Works Vertical Construction Projects," Sept. 20, 2023.

REQUIREMENT 3: Evaluation of Barriers to Incorporating Innovative Techniques

Background on innovative construction techniques

Innovative construction techniques can be described as products or techniques that depart from the traditional means of construction and further advance sustainability through efficiency. One example of an innovative technique is additive manufacturing (also known as 3D printing), which may include the automated process of “printing” a three-dimensional solid object from a digital file using concrete as a medium. Another example is the use of sensor data to capture and update construction progress in real time.

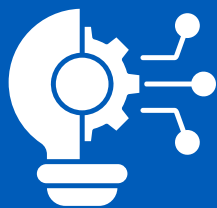
Both examples may provide a more efficient means of construction and construction management, respectively, but are not yet widely used by the construction industry. Innovative techniques typically require evaluation, demonstration, and validation before industry—and DOD—accepts the technique as a best practice or standard. Whereas innovation in industry is driven mostly by profit, innovation in DOD is driven by mission requirements.

Study findings

The timely transition of innovative technologies and techniques is a recognized concern across DOD, not solely for the MilCon program. An examination of potential drivers for innovative construction techniques for MilCon revealed several barriers to their use:

- Financial concerns
- Lack of a forcing function
- Lack of a formalized process for technique evaluation
- Lack of knowledge among laboratory staff, designers, and laborers

First, there are financial concerns regarding perceived or actual upfront costs, including the cost of hiring skilled labor to perform innovative techniques. Second, DOD does not have forcing functions (e.g., requirements to take action, measurable goals) to either identify innovative construction techniques or increase the inclusion of such techniques into MilCon. In addition, although UFC documents generally do not prohibit the use of innovative



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construction techniques, such techniques may not be included in contract specifications because the inclusion of a construction methodology may be considered too prescriptive by a MilCon project team. In this regard, 48 CFR Subpart 552.236-71, "Contractor Responsibilities," was mentioned as prohibiting MilCon project teams from directing the means and methods of the construction contractor. Third, there is a lack of a formalized process for laboratories to identify and assess innovative construction techniques, which speaks to a lack of knowledge about the availability of such techniques. Fourth, successful validations and demonstrations have not been communicated well to components and potential stakeholders; there is no established means for broadcasting these results effectively.

One way in which DOD is advancing innovation is by leveraging existing contracting mechanisms to enable the adoption of innovative techniques. Commercial Solutions Openings are flexible, competitive solicitation instruments that DOD may use to acquire innovative commercial products, technologies, services, and other research and development needs.⁹ The Defense Innovation Unit may facilitate this solicitation process or provide alternative methods for rapid innovation adoption such as Other Transactions Agreements, which have already been used with some success at NAVFAC EWXC.¹⁰

ERDC and EXWC have also participated in the evaluation of sustainable materials and products and innovative construction techniques, and they could do more. Both labs have established relationships with UFC working groups.

⁹ Stephen Speciale and Danny Poskey, "Commercial Paths for Acquiring Innovative Technologies," Defense Acquisition, accessed Apr. 2, 2024, <https://www.dau.edu/datl/b/commercial-paths-acquiring-innovative-technologies>.

¹⁰ Defense Innovation Unit, "Solve Your Toughest Problems with Commercial Technologies at Commercial Speeds," accessed Apr. 4, 2024, <https://www.diu.mil/work-with-us/dod-entities>.

REQUIREMENT 4: Evaluation of SERDP or ESTCP for Validating Such Sustainable Materials and Innovative Techniques to Encourage Their Use by USACE and NAVFAC

Background on DOD laboratories and technology demonstrations

SERDP serves DOD in the development of technologies to address high-priority DOD environmental problems affecting mission readiness and environmental liabilities. R&D is performed in partnership with the Department of Energy, the Environmental Protection Agency, and other federal and nonfederal agencies. SERDP invests in a wide variety of basic and applied research and advanced development of identified technologies.

ESTCP performs demonstration and validation of environmental and installation energy technologies to address high-priority DOD problems affecting mission readiness and environmental liabilities. The program demonstrates how innovative, cost-effective environmental and energy technologies capitalize on past investments. ESTCP conducts efforts to transition technology “out of the lab” (i.e., not yet commercially available) and promotes implementation of technology through facilitating regulatory acceptance.

The DOD STED program, funded through ESTCP, was established to evaluate, demonstrate, and transition sustainable technologies and products that are commercially available and align with DOD and federal agency mission requirements. Objectives of the program are identifying emerging sustainable technologies that meet DOD needs, evaluating technical data of sustainable alternatives

against military specifications and other government requirements, and conducting demonstrations at DOD installations and other federal agency facilities.

Both ESTCP and STED conduct technology demonstrations that serve to prove the technologies in operational environments and compare them to traditional products. Demonstrations also serve to collect cost and performance data—such as life-cycle analysis and evaluation of advertised sustainability metrics of both new and existing technologies—to assess and evaluate technical and programmatic risks. Developing cost and performance data is important for overcoming perceived barriers to employing an innovative technology because of concerns about technical or programmatic risk.

Study findings

SERDP, ESTCP, and the STED program are poised to support additional efforts in the validation of increased thresholds for sustainable materials and products and innovative construction techniques. However, there is not an identified list of MilCon technology gaps, even though study topic areas and funded projects for ESTCP and STED have included sustainable materials and innovative construction techniques, and previously funded projects for these programs have led to the transition of innovative technology used in MilCon. Although recent projects funded by SERDP have not focused on materials and technologies related to MilCon, the program

has processes in place to support the research of sustainable materials and innovative construction techniques.

In addition, even though ESTCP and STED support efforts to validate use of sustainable materials and innovative techniques that may be included in MilCon projects, the transitioning of validated materials and techniques is not always successful. The successful transition of new materials and techniques and their subsequent use in MilCon projects require the programs to submit performance data, via CCRs, to the applicable UFC DWG and functional working group (FWG) for assessment. The performance data should align with the applicable industry standard, such as the International Building Code or the International Green Construction Code. Otherwise, the UFC DWG/FWG responsible for assessing the use of a particular material or technique will likely reject the CCR.

One example of a successful transition to a sustainable product was the STED program's demonstration of an insulated interior and exterior door system that was reported to offer improved efficiency compared to traditional hollow metal doors. The demonstration resulted in validating energy savings of up to 1,578 kWh per year per door. The door's performance was found to meet the criteria in UFC documents, and it may be used in MilCon projects.

Furthermore, DOD and the General Services Administration (GSA) signed a memorandum of understanding in March 2023 to help expedite bringing environmental innovations into the federal marketplace. Under the agreement, the GSA will use product performance data obtained from the STED program to help vendors secure a new Federal Supply Schedule and, potentially, a National Stock Number. This effort has the potential to improve not only the identification and procurement of sustainable products but also the awareness and availability of those products.¹¹

¹¹ General Services Administration, "Industrial Products & Services—DOD STED MOU Success Story," 2023.

CONCLUSION

Industry and government have shown an interest in increasing sustainability and innovation in major construction projects. And current DOD guidance and UFCs support increased usage of sustainable materials and innovative techniques. However, determination of how to include increased thresholds for sustainable materials and innovative techniques is unclear. In addition, DOD and service component laboratories provide a means of identifying and developing innovative solutions for technology gaps, yet there are no clearly identified technology

gaps or forcing functions to increase the inclusion of such solutions into MilCon. Although some advances have been made in transitioning materials, such as the current efforts focused on the inclusion of mass timber in MilCon, further inclusion of additional materials, increased minimum thresholds for material properties, and techniques are largely stifled by either a lack of industry standards or ineffective communication of laboratory demonstration results to MilCon stakeholders.

ABBREVIATIONS

CCR	Criteria Change Request
CP	Coordinating Panel
DOD	Department of Defense
DWG	Discipline Working Group
ERDC	Engineer Research and Development Center
ESEP	Engineering Senior Executive Panel
ESTCP	Environmental Security Technology Certification Program
EXWC	Expeditionary Warfare Center
FWG	functional working group
GSA	General Services Administration
HPSB	High Performance and Sustainable Building
MilCon	military construction
NAVFAC	Naval Facilities Engineering Systems Command
SERDP	Strategic Environmental Research and Development Program
STED	Sustainable Technology Evaluation and Demonstration
UFC	Unified Facility Criteria
UFGS	Unified Facility Guide Specifications
USACE	United States Army Corps of Engineers

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An aerial photograph of a dense, lush green forest, likely a tropical rainforest, with various shades of green and some palm trees visible. The image is used as a background for the CNA logo and text.

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