Biocementation Rapid Experimentation and Applications Laboratory

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Short Description

The Biocementation Rapid Experimentation and Applications Laboratory (BioREAL) will provide the USAF and industry with a unique, specialized capability to enable the rapid assessment, maturation, and demonstration of biologically-hardened materials and structures to sustainably support future aerospace operations from austere environments. The project addresses current testing infrastructure shortfalls to accelerate transition of this new class of materials to meet both defense and civil needs.

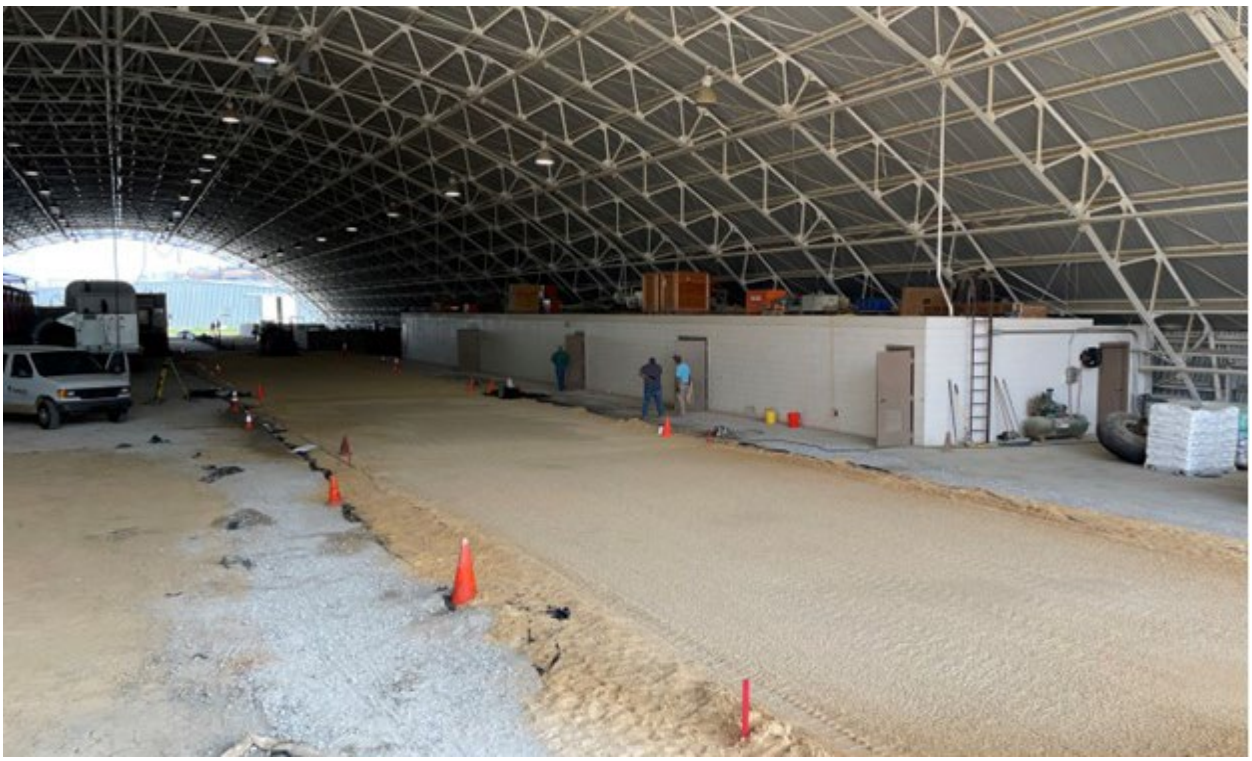
Discussion

The U.S. military increasingly needs to operate in austere environments with little-to-no baseline infrastructure in place. Conducting operations in such environments with heavy equipment, large volume vehicular traffic, more powerful vertical lift aircraft, and larger numbers of conventional and uncrewed fixed wing aircraft poses significant operational and logistical challenges, especially in any future near-peer contested environments. Accordingly, many recent shifts in military doctrine – such as the USAF's Agile Combat Employment (ACE) and the Navy/Marine Corps' Expeditionary Advance Base Operations (EABO) – must focus on the development and deployment of novel expeditionary infrastructure generation utilizing methods and materials outside of established construction practices. These new "Just Enough, Just In Time" approaches (as coined by the U.S. Army Corps of Engineers) increasingly leverage novel construction materials (e.g., biocement, polymers, enzymes, etc.) and methods (e.g., in-situ growth, 3D printing, etc.) that require significant development and testing before adoption by the warfighter.

Expeditionary Airfields. Representative examples of expeditionary landing zones and airfields across vehicle class operations, ranging from small uncrewed systems to large cargo aircraft.

Key among ACE/EABO efforts are those associated with rapid construction and repair of runways/airfields. The current state of the art in construction and Rapid Airfield Damage Repair (RADR) utilizes conventional approaches, requiring significant manpower, equipment, and materials. Developmental agendas such as Expedient Airfield Damage Repair (E-ADR) and various USAF-supported efforts in augmented expeditionary surfaces involve investigating the use of novel construction methods and materials to meet adaptive basing objectives. These airfield repair development efforts are now firmly established and largely centered at the Air Combat Command's Silver Flag test site at Tyndall AFB, but lack capabilities for supporting iterative materials research and development programs involving experimental cycling, iterative performance evaluations, and qualification requiring baseline data under controlled conditions.

Located in Vicksburg MS, the USACE Engineering Research and Development Center (ERDC), provides a useful template with its Pavement Testing Facility, where iterative testing may be executed at relevant scales to evaluate systems application/process, soil/substrate type dynamics, simulated environmental conditions, experimental non-destructive testing methodologies, and endpoint performance evaluations (aircraft/vehicle load carts). While useful for evaluating materials for Army applications, the facility does not have the necessary infrastructure to simulate conventional jet engine, high-speed vertical takeoff and landing (HS-VTOL), and electric VTOL under controlled aerothermodynamic conditions necessary for USAF research.



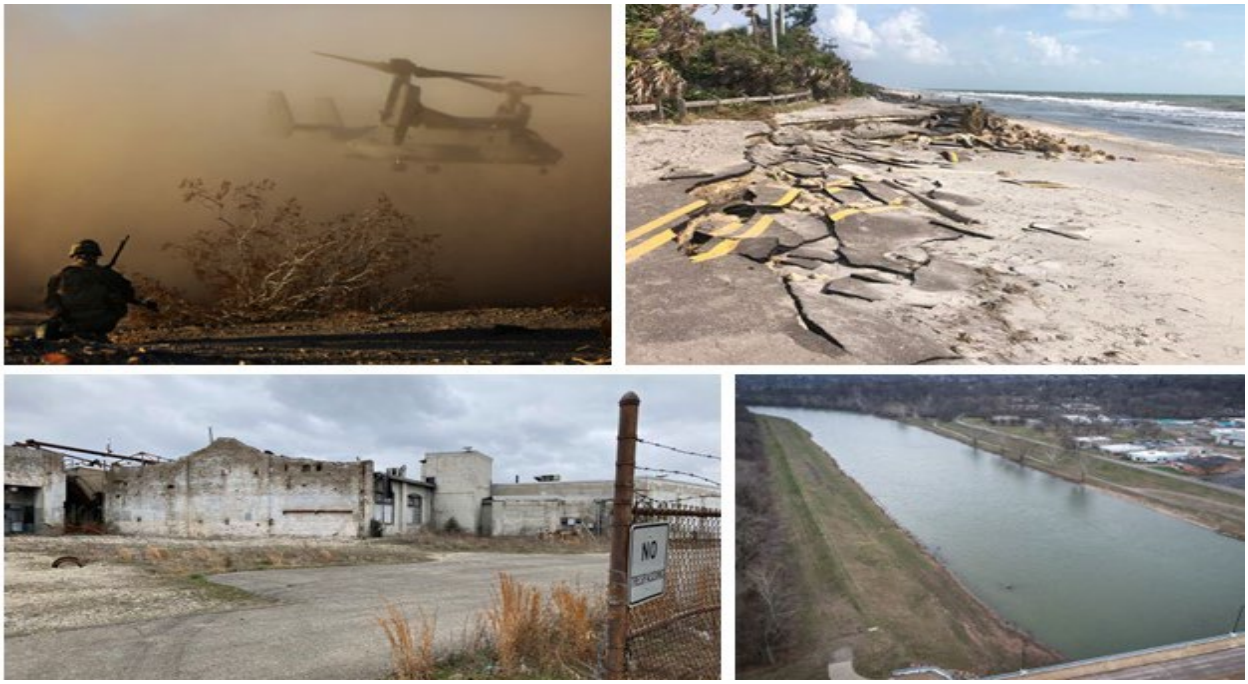
USACE-ERDC Pavement Testing Facility. While useful for tests and demonstrations of pavement materials, the facility is not suitable to support materials R&D for aircraft applications.

Since 2019, multiple complementary efforts funded by the Defense Advanced Research Projects Agency (DARPA) and the Air Force Research Laboratory (AFRL) have focused on airfield

construction/repair utilizing biocement – a calcium carbonate crystal binder generated by soil microbes. Much of this work to date has been executed in small, lab-based testbeds and makeshift field test sites, with limited ability to appropriately evaluate performance of these novel, biologically augmented surfaces, highlighting a need for a suitable facility to enable iterative requisite scaled testing to assess, mature, demonstrate, and transition the most promising technologies to meet future airfield operational needs.

A research facility combining both digital simulation capabilities and experimental capabilities – to include environmental testing (temperature, humidity, etc.), compression and load cycling, rain/erosion experimental simulation, jet exhaust and rotor downwash experimental simulation, and data collection and visualization capabilities under controlled and repeatable conditions – would rapidly accelerate testing, demonstration, and qualification of various material solutions at appropriate scales, prior to expensive and coordination-intensive field tests involving operational aircraft and aircrews. Proposed to be located in Beavercreek, OH, adjacent to Wright-Patterson AFB with its array of key Air Force stakeholders (HQ AFMC, AFRL, AFLCMC, and AFIT), the BioREAL project aims to provide this unique and needed capability.

The BioREAL facility may also be tailored to include relevant infrastructure and utilities to support testing and evaluation of a range of civilian flight systems, such as dust abatement for Advanced Air Mobility (AAM) concepts, including next generation eVTOL vehicles. In addition to flight systems infrastructure, the BioREAL facility would be capable of supporting active biocement applications development for non-aerospace applications, such as erosion control and levee/floodplain management, and an array of potentials for soil contamination bioremediation (such as those affecting military installations like Wright-Patterson AFB and other bases).



Additional Biocement Applications. *Right panels, clockwise from top-left*: dust abatement, erosion control, levee stabilization, and brownfield remediation.