U.S. ARMY

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Materials and Manufacturing Tech
Full Project Lifecycle Sustainability

Robert D. Moser, Ph.D., SSTM - robert.d.moser@usace.army.mil
Eric L. Kreiger - eric.l.kreiger@usace.army.mil

Engineer Research and Development Center
US Army Corps of Engineers

Widening the Lens on Innovation for Clean Manufacturing

17 February 2021

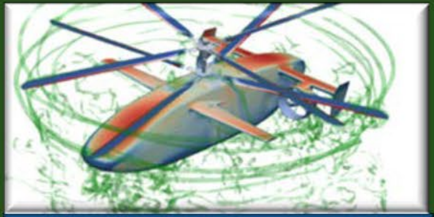
US Army Corps of Engineers®

ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER
Innovative solutions for a safer, better world

ERDC RDAs

RESEARCH AND DEVELOPMENT AREAS THAT DELIVER SOLUTIONS

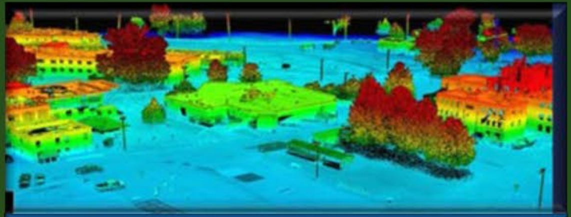
MILITARY ENGINEERING



ENGINEERED RESILIENT SYSTEMS

CIVIL WORKS

INSTALLATIONS AND OPERATIONAL ENVIRONMENTS



GEOSPATIAL RESEARCH & ENGINEERING

CORE COMPETENCIES

SPECIALIZED ERDC KNOWLEDGE THAT ENABLES OUR RESEARCH AND DEVELOPMENT AREAS

BLAST AND WEAPONS EFFECTS
ON STRUCTURES AND GEO-MATERIALS

CIVIL AND MILITARY ENGINEERING

BATTLESPACE
TERRAIN MAPPING AND CHARACTERIZATION

COLD REGIONS SCIENCE AND ENGINEERING

MILITARY INSTALLATIONS AND INFRASTRUCTURE

COMPUTATIONAL PROTOTYPING OF MILITARY PLATFORMS

COASTAL, RIVER, AND ENVIRONMENTAL ENGINEERING

Materials and Manufacturing R&D

Supporting Army S&T, USACE, and Military and Civilian Stakeholders and Partners in ERDC Core Competencies:

- *Blast and Weapons Effects on Structures and Geomaterials*
- *Civil and Military Engineering*
- *Military Installations and Infrastructure*
- *Cold Regions Science and Engineering*

ERDC
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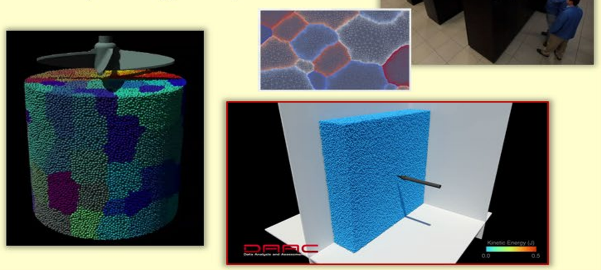
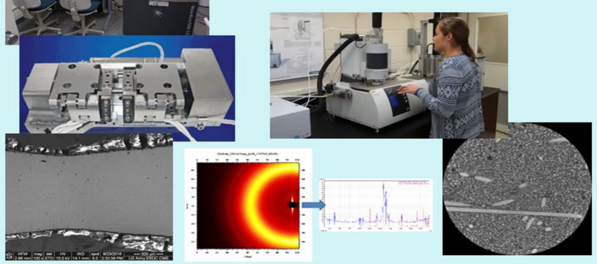
Cutting-Edge Blast, Impact, and Penetration Testing Equipment

Large-Scale Structural Testing Systems

High-Performance Computing Capabilities



Materials Analysis and In-Situ Mechanics



Force Protection and Weapons Effects

- Advanced weapons effects
- Multi-functional materials
- Structural hardening
- Indigenous materials

Force Projection and Maneuver Support

- Rapid repair and retrofit
- Lightweighting
- Indigenous materials
- Remote assessment

Infrastructure, Installations & Environment Quality

- Sustainability
- Operational energy
- Life-cycle durability / performance
- Environmental impacts

Cross-Cutting Technologies

- Additive / advanced manufacturing
- Multi-scale modeling
- Robotic platforms
- Artificial Intelligence
- Advanced measurement science

Leveraging Extramural Research Partnerships and Advanced High-Performance Computing Capabilities

Sustainability and Climate Change Drivers (or lack thereof)

Civil Works

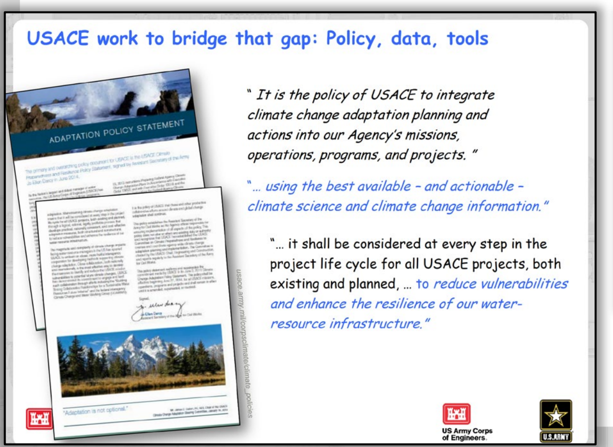
- Aging infrastructure burden outweighs new infrastructure
- Limited sustainability drivers for materials and construction
- Strong emphasis on 100+ year service lives, service life extension, and asset management
- Long-standing practices that have sustainability benefits

Military

- Post 9/11 threats transition towards peer and near-peer
- Modernize to fight and win
- Limited direct drivers for sustainability and climate change
- Operational impacts of climate change on warfighting functions
- Energy, water, and natural hazard resilience drives modernization

Opportunities

- Sustainability and climate resilience drivers are forefront drivers
- People and $$ applied toward action on climate change and resilience
- R&D initiatives growing in:
  - Nature based solutions
  - Multi-hazard resilience
  - Design / materials / manufacturing nexus
  - Advanced materials-by-design (+biotech)
  - Manufacturing / construction processes

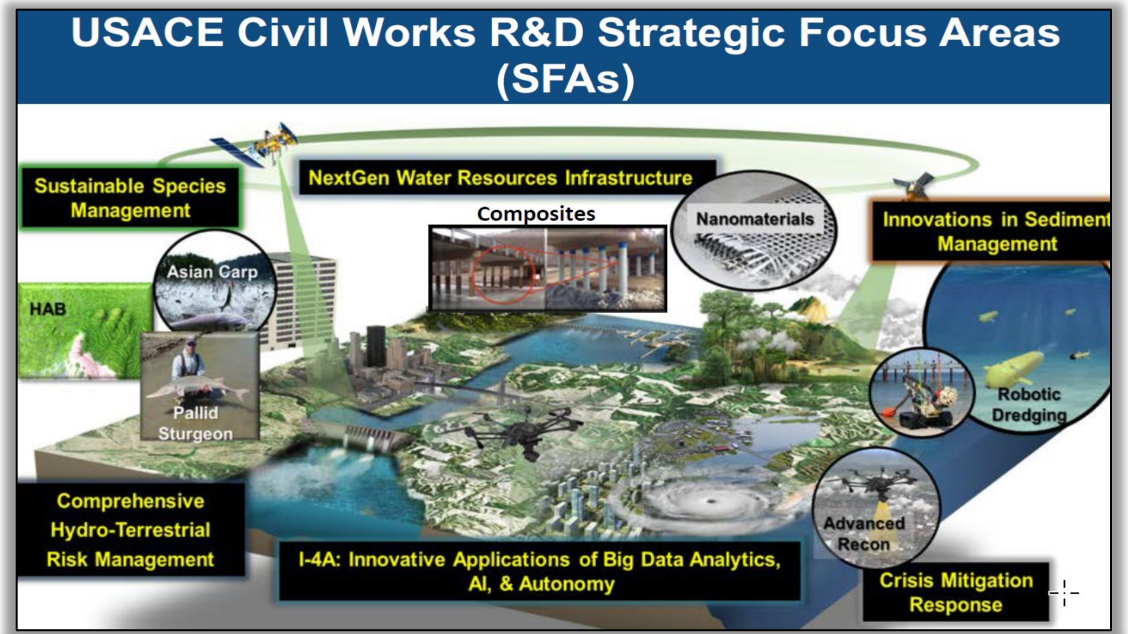


Executive Order 14008 of January 27, 2021

Tackling the Climate Crisis at Home and Abroad

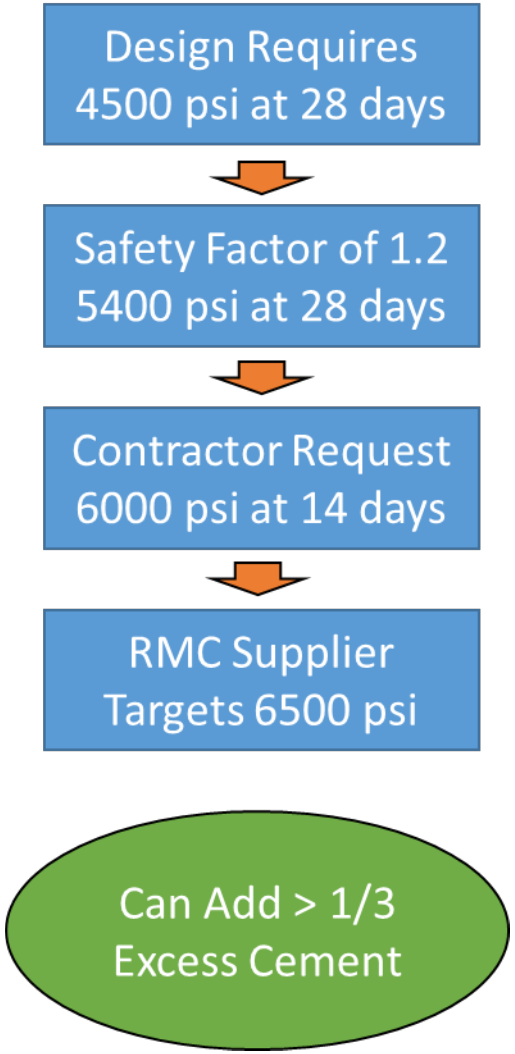
The United States and the world face a profound climate crisis. We have a narrow moment to pursue action at home and abroad in order to avoid the most catastrophic impacts of that crisis and to seize the opportunity that tackling climate change presents. Domestic action must go hand in hand with United States international leadership, aimed at significantly enhancing global action. Together, we must listen to science and meet the moment.

Source: Dr. Kate White, USACE Climate Change and Resilience Community of Practice Lead



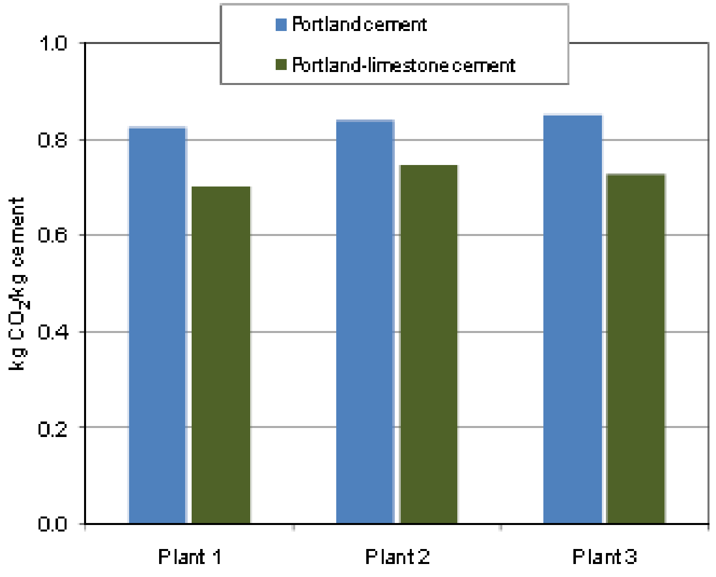
Particular Considerations in Construction Materials

- Large drivers in cement, geomaterials, construction, and other high-energy manufacturing processes
- Construction industry relies on commodity products
- Construction materials are cheap: economic and policy drivers needed to generate action
- We need to think beyond steel and concrete
- Materials and lifecycle design are hand-in-hand
- We must think full life-cycle: design, manufacturing, construction, operations, disposition
- Many professions (some may call them tribes) must work together to innovate in construction
  - Researchers, engineers, policy, training, academia manufacturers, contractors, and labor workforce

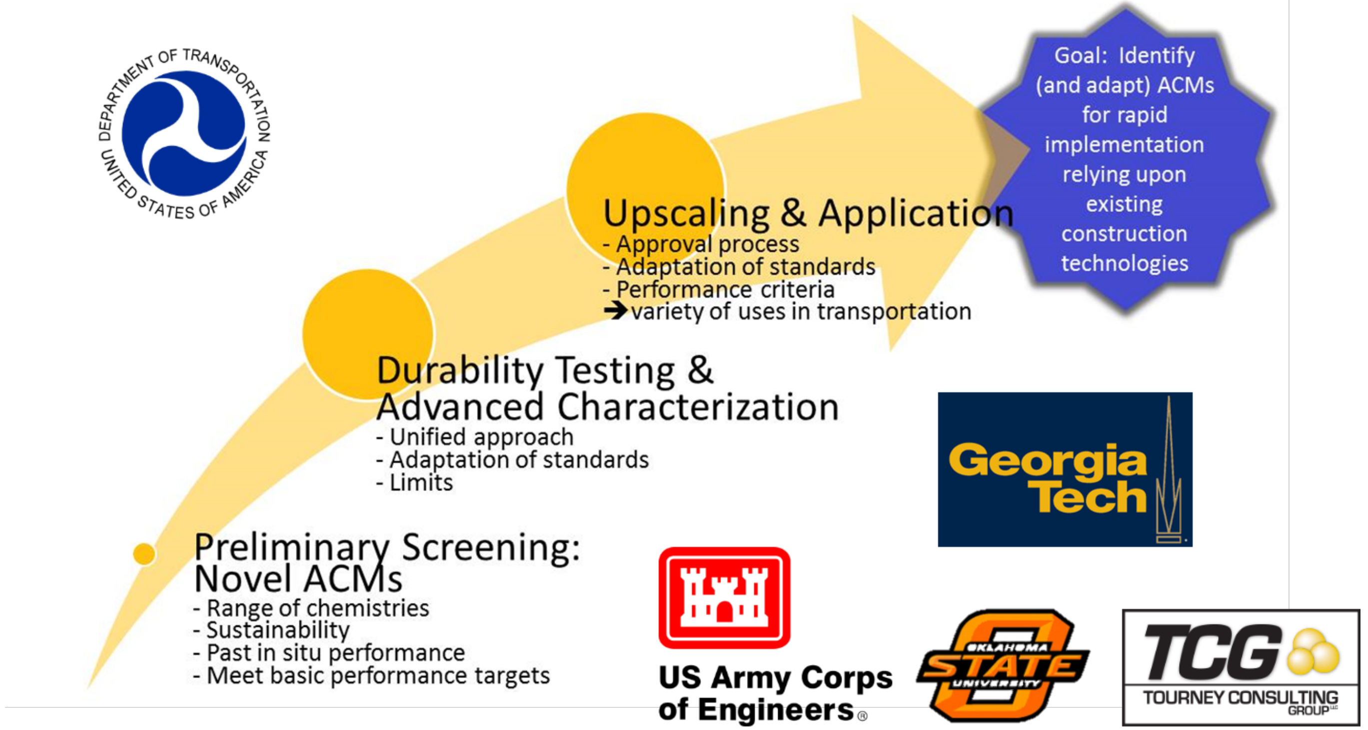


Alternative Cement Chemistries

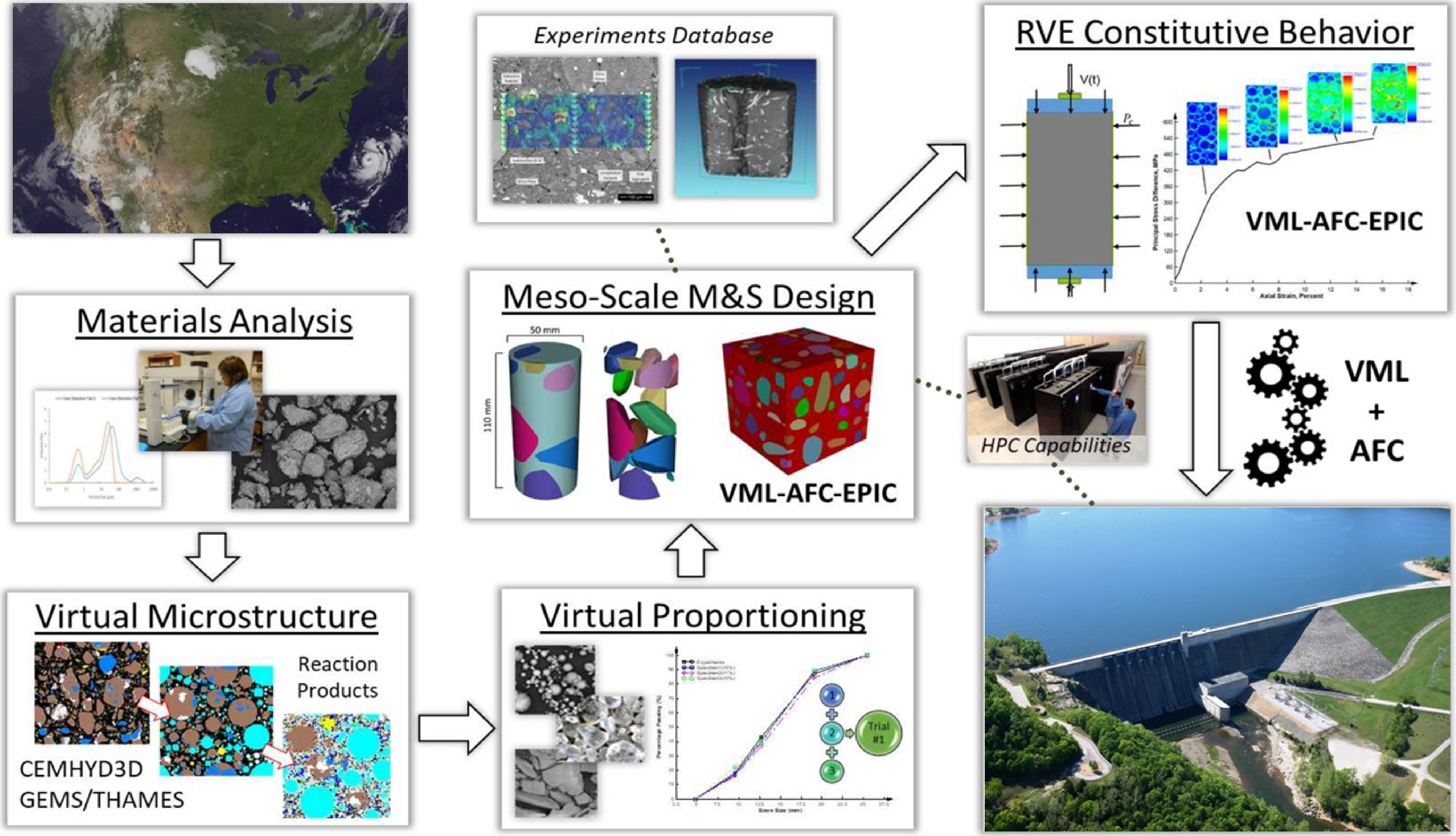
- Portland Limestone Cement
- Specifications
  - ASTM C1157
    - Type GU or MS
  - ASTM C595 or AASHTO M240
    - Type IL



- Alternative Cementing Chemistries
  - Multiple activities Civil and Military
  - Leveraging experience in specialty military apps
  - PLC, CSA, CAC, MPC, LC3, Belite, Carbonating…
  - along with manufacturing innovations…

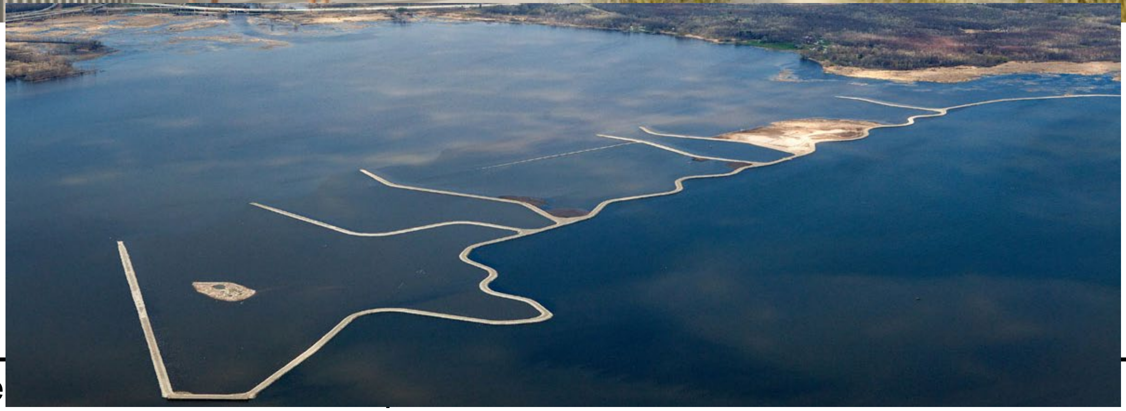


Construction Materials-by-Design



Nature-Based Solutions

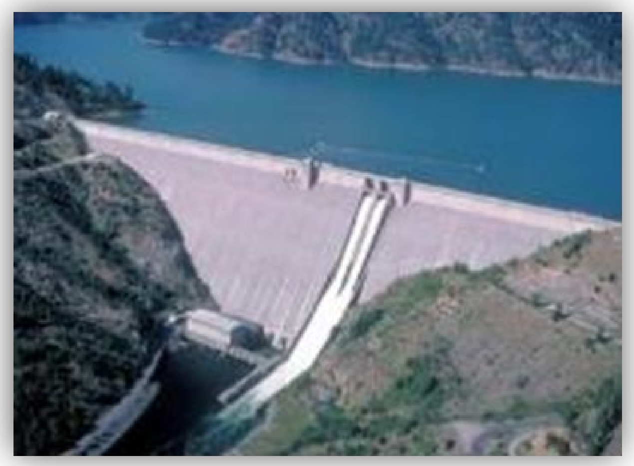
- Supported through the USACE Engineering With Nature initiative
  - Natural solutions as opposed to hard civil works infrastructure
  - Science and engineering that produces operational efficiencies
  - Using natural process to maximum benefit beyond built projects
  - Broaden and extend the benefits provided by projects



Aging Civil and Military Infrastructure Challenges

- Complex portfolio of civil works and military facilities
- Materials: concrete to steel…timber to polymers
- Operational facilities built as early as late 1800s
- ERDC supports Tri-Services R&D on aging infrastructure

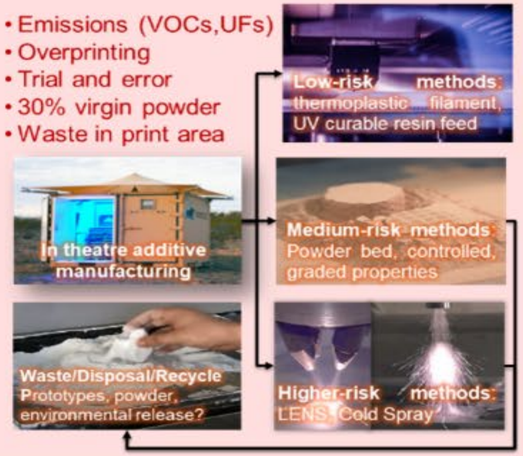
How do we ***understand current state***, ***predict future state***, and use this information to ***shape outcomes*** in a limited funding environment?



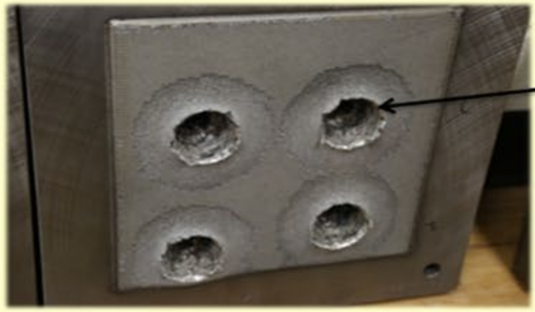
Advanced Manufacturing R&D Focus Areas

Additive Construction Technology Development and Demonstration

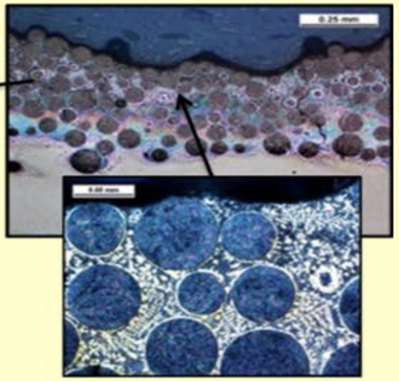
Environmental Sustainability of Additive Manufacturing



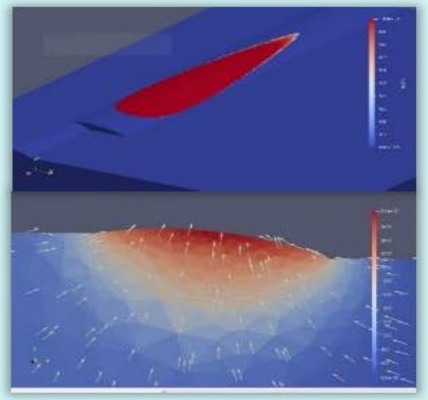
Advanced and Lightweight Materials Enabled by Additive Manufacturing

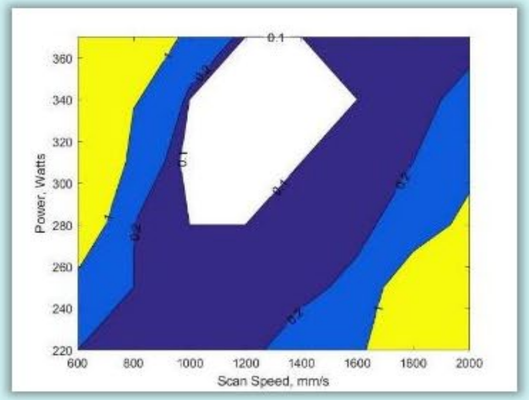


IN625 + WC Coated A36 plate subjected to fragment simulating projectile testing.



Computational Tools for Design and Manufacturing Process Optimization





Additive Construction

Problem

- Expeditionary Structures are:
  - Labor intensive
  - Energy expensive
  - Material expensive

Solution

- 3D print custom-designed expeditionary structures on-demand, in the field, using locally available materials.

Impact

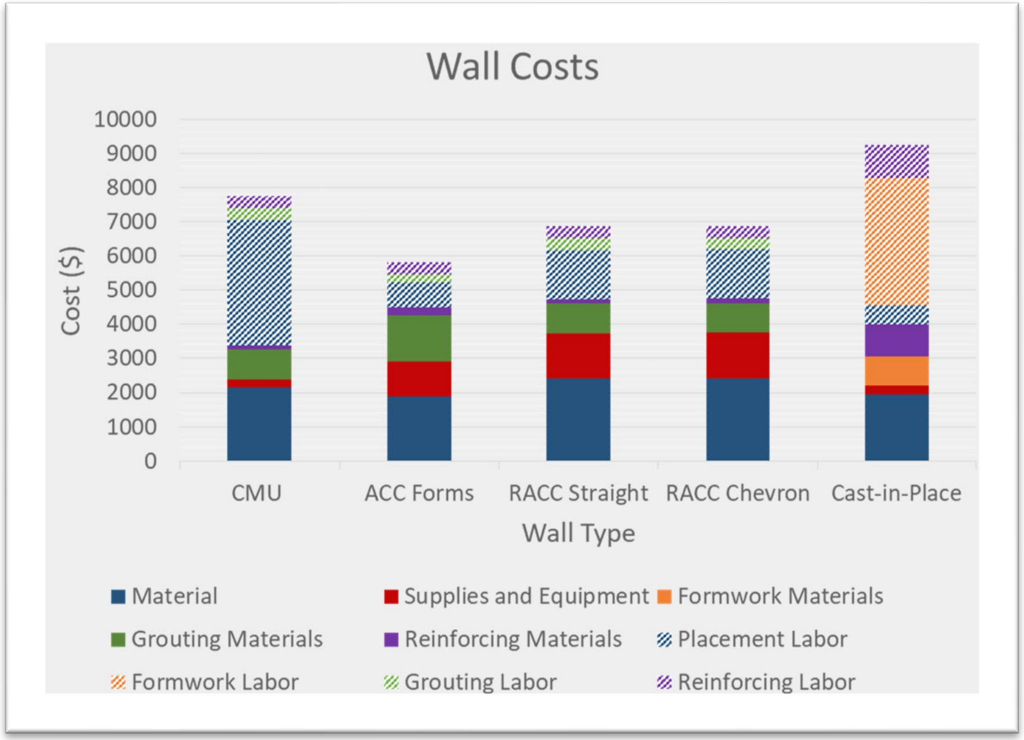
- Saves time
- Saves money
- Saves material
- Saves energy/fuel
- Reduction in hard labor & manpower
- Improved protection

Contact : eric.l.kreiger@usace.army.mil

Additive Construction

Sustainable Solutions

- Reduction of concrete materials and reinforcement materials through optimization
- Reduced logistics (Diesel)
- Removal of formwork (time, logistics, and cost)
- Improved energy performance
- Exploration of impact of alternative materials
    - Alternative cements
    - Low conductivity aggregates
    - Supplementary cementitious materials (Fly ash, silica fume, etc.)
    - Polymer concrete
    - Metal
    - Polymers



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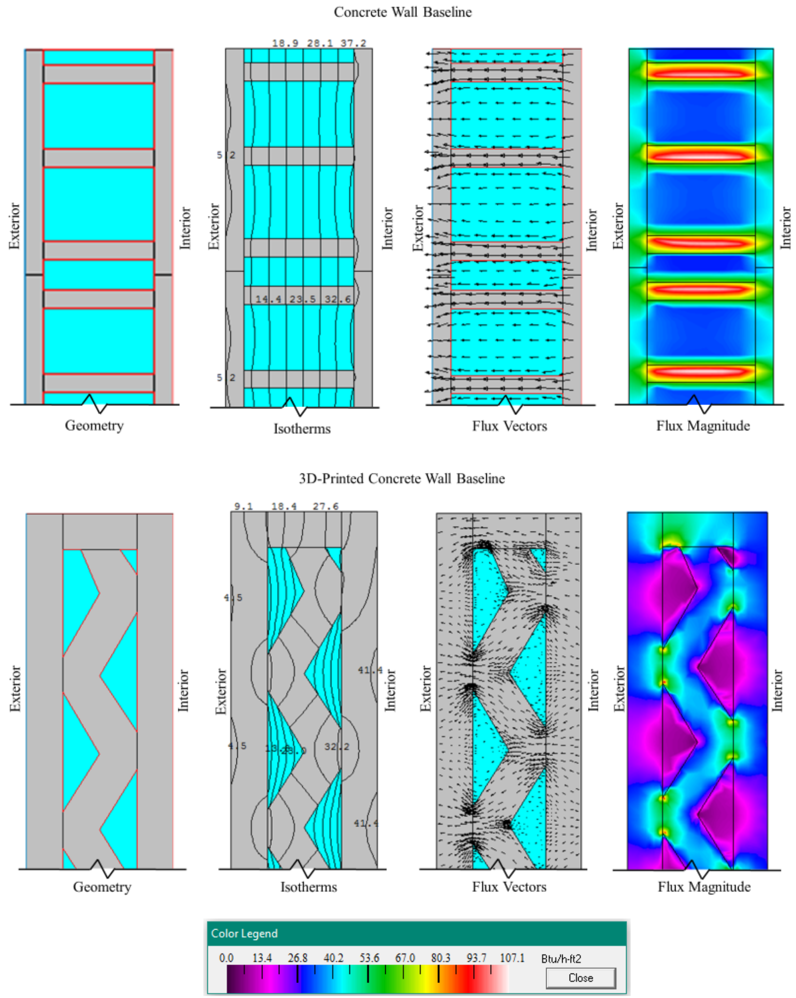
Contact : eric.l.kreiger@usace.army.mil

Additive Construction

Energy Performance

- Energy and thermal modelling
- Thermal testing
- Design through geometry
- Comparable or better than CMU construction
- Reduced embodied energy
- Shorter construction times
- Optimized material usage
- Baseline R-value similar to CMU for walls



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DISCOVER • DEVELOP • DELIVER
new ways to make the world safer and better

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