Materials, Concrete, and Geotechnical Laboratories

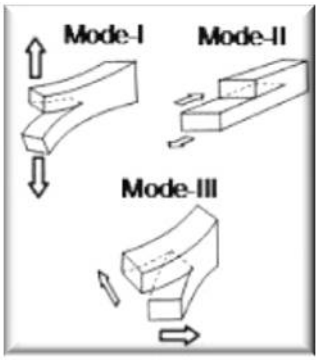
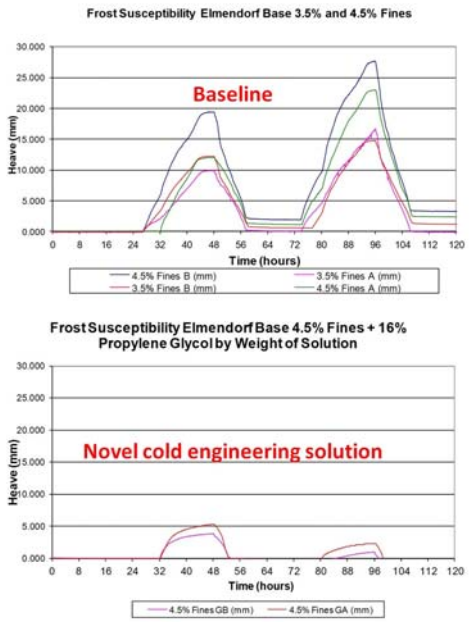
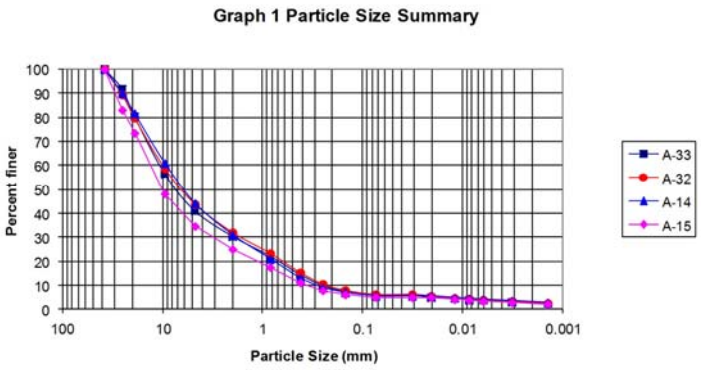
Customized Materials Development, Testing, and Evaluation in Realistic Environments

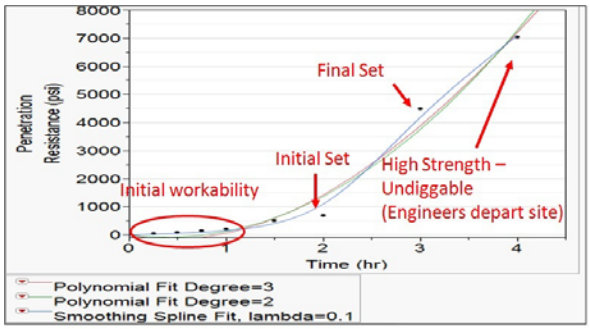
CRREL's combination of materials, concrete, and geotechnical laboratories consist of a variety of equipment, instrumentation, and dedicated and experienced test engineers and technicians to effectively quantify behavior characteristics of a wide range of materials in realistic environmental conditions found throughout the globe. Because of CRREL's focused expertise in cold regions engineering, our engineers, scientists, and technicians have pioneered materials testing standards and methods in a variety of areas where standards either have not existed or are insufficient to address specific problems. Previous activities in these combined laboratories include the following:

- Soils classification testing
- Sieving, hydrometers, Atterberg limits, specific gravity, moisture content
- Freeze-thaw investigations including thaw consolidation, frost heaving (cyclic effects or one-time freeze-thaw cycle), other
- Thermal properties and thermal conductivity physical testing to provide inputs to thermal modeling studies
- Materials strength and other mechanical properties investigations
- Hydraulic conductivity
- Cold weather concrete and flowable fill materiel development for DoD use in contingency environments
- Development of methods to quantify ice adhesion effects, materiel evaluation, and materiel development
- Unsaturated flow phenomena
- Short, long term creep
- Low temperature, low strain rate testing (flexural fatigue - multi-point bending, other)
- Low temperature, high strain rate testing (brittleness index studies, materials fracture and associated phenomenology, other)
- Thermal stress
- Shrinkage
- Soil physics (fundamental behaviors)
- Capillary barriers phenomenology

Engineering Resources Branch technicians prepare steel cables for cold weather (-40 °F) tension testing using one of three CRREL machines for low

The Split-Hopkinson Pressure Bar apparatus is used for high strain-rate testing at low to moderate temperatures (compression, tension, or torsion).

temperature, low strain rate materials testing. (Photo by Jared Oren, ERDC-CRREL)	(Photo by Jared Oren, ERDC-CRREL)
	 • Mode I Tensile opening • Mode II In-plane shear • Mode III Anti-plane shear
CRREL researchers quantify the effects of ice adhesion on prototype coatings applied to metals using a CRREL-developed standard method called the zero degree cone test. (Photo by Tom Hall, ERDC-CRREL)	**CRREL researchers develop a variety of methods to analyze and address problems caused by ice adhesion on equipment, vehicles, and systems through a systematic physics and materials engineering-based approach.** (Photo by David Cole, ERDC-CRREL)
	
CRREL researchers quantify the frost susceptibility of soils and develop a solution to minimize soil heaving for a runway at Joint Base Elmendorff-Richardson (JBER). (Photo by Jared Oren, ERDC-CRREL)	**Routine soils classification testing (photo) constitute typical initial investigation steps for a wide range of studies in the geotechnical laboratory, to include: methods and materiel development for soils stabilization, frost heave and thaw effects analysis and mitigation, and mobility studies.** (Photo by Charlie Smith, ERDC-CRREL)



Results of laboratory testing for concrete mix using admixture combination Calcium Chloride 4%, Calcium Nitrate 15% at -5 ◦C nominal Temperature and w/c .40. Concrete solution developed for US Army for operations in Afghanistan.

CRREL researchers develop a custom cold weather concrete materiel solution for the US Army in Afghanistan, enabling roadway repairs with cheap, locally procurable materials in 20-25% of the time required for conventional construction methods and materials.

(Photo by Jared Oren, ERDC-CRREL)

TJ Melendy, research civil engineer in the Force Projection and Sustainment Branch at CRREL, tests the unconfined compressive strength of a novel cold weather concrete developed for the US Air Force Civil Engineering Center (AFCEC) as part of its Rapid Runway Repair Modernization Program.

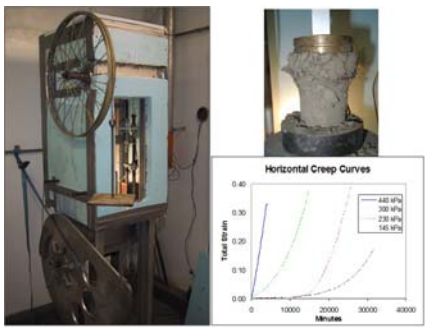
(Photo by Jared Oren, ERDC-CRREL)

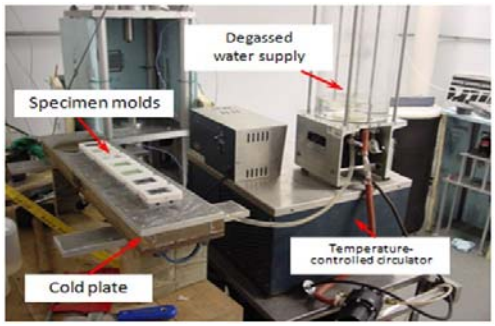
CRREL researchers use a custom frost heave apparatus to conduct a variety of investigations related to soil susceptibility to cyclic or one-time freeze-thaw cycles.

(Photo by Jared Oren, ERDC-CRREL)

The soils physics lab consists of a variety of instrumentation and equipment developed at CRREL for investigations related to understanding the fundamental characteristics and behaviors of soils.

(Photo by Jared Oren, ERDC-CRREL)





CRREL researchers use a custom creep apparatus to examine the short and long term effects of horizontal

CRREL has developed a number of methods and equipment to reliably quantify the effects of ice adhesion, including the

and vertical soils creep on structures and pavements. (Photo by Kevin Bjella, ERDC-CRREL)	**freshwater ice preparation system shown above.** (Photo by David Cole, ERDC-CRREL)

Success Stories

The US Coast Guard (USCG) and the US Navy (USN) have become increasingly concerned about the effects of ***ice adhesion*** on their vessels entering Arctic waters, and are interested in materiel development solutions which offer anti-icing and de-icing advantages. CRREL has long led the technical community with developing a variety of tests to quantify the effects of ice adhesion on materials and equipment in order to aid in the development of better technologies for anti and de-icing. In response to the USCG and USN's needs, CRREL has ***pioneered a new technique*** called the "peel test," which is appropriate for quantifying the effects of sea ice adhesion in certain fracture modes. See POC list for more information.

The US Army has been concerned in recent years about its ability to ***rapidly repair roadways*** in contingency environments such as Iraq and Afghanistan using Army Engineer existing equipment, its associated engineer soldiers. A broad technical community responded to this challenge over time with a variety of solutions, none of which were suitable in ***cold weather*** (near or sub-freezing temperatures). CRREL responded to this need by developing a custom cold weather concrete solution for the US Army in Afghanistan, enabling roadway repairs with cheap, locally procurable materials in 20-25% of the time required for conventional construction methods and materials.

A portion of a runway for military aircraft at Joint Base Elmendorff-Richardson (JBER) in Anchorage, Alaska was recently experiencing severe ***frost heave and thaw settlement damage*** due to the cyclic freeze-thaw environment experienced by the runway pavement and its sub-layers. CRREL researchers developed a frost susceptibility apparatus and other related equipment to quantify the frost susceptibility of the JBER soils and develop a novel geotechnical solution to minimize soil heaving for the runway, saving an estimated millions of dollars in construction costs versus alternative known remediation methods.

Features

- Three apparatuses for **low to moderate temperature, low strain rate materials testing**. Typical studies include soil triaxial shear, soils hydrostatic compression, ice adhesion, cyclic tension or compression testing for a variety of materials including composites, and other topics:
    - Heavy load materials testing machine – 1,110 kN (250,000 lbf) capacity; temperature range -70 to 40(+) ◦C; includes dual servo valves for high cyclic rate testing (100 load cycles / min)
    - Soils lab materials testing machine – 110 kN (25,000 lbf) capacity; temperature range -20 to 40(+) ◦C
    - Composites lab materials testing machine – 220 kN (50,000 lbf) capacity; temperature range -150 to 40(+) ◦C; includes dual servo valves for high cyclic rate testing (100 load cycles / min)
    - Typical instrumentation:
        - MTS FlexTest Digital controllers to automate testing and provide real-time, customized displays
        - Temperature controls (+/- 0.5 ^{o}C typical)
        - Extensometers and LVDTs for high precision position and dimensions information
- multi-point bend apparatus for **flexural fatigue testing** – 133 kN (30,000 lbf) capacity
- **creep** apparatus for quantifying vertical, horizontal soils creep in minutes to weeks/months; temperature range -20 to 40(+) ◦C
- a Split-Hopkinson pressure bar and Charpy impact machines for **low to moderate temperature, high strain rate materials testing**
- **Ice Adhesion** test setup, execution, and data collection apparatuses (fresh, sea ice in different fracture modes)
- **Concrete freeze / thaw cycling chamber** for studying the effects of freeze-thaw or other thermal cycles on concrete
- **Frost susceptibility apparatus f**or studying the effects of freeze-thaw cycles on **soils** and other materials
- Other custom materials testing equipment
- Contact Jared Oren for a variety of methods to conduct **real-time remote** (or on-site) **controls and monitoring** through LabView. In addition, a dedicated, secure website and other functionality is possible for **remote video and photo monitoring**.

ERDC Points of Contact

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More information on CRREL's other facilities and capabilities here:
http://www.erdc.usace.army.mil/Locations/ColdRegionsResearchandEngineeringLaboratory/CRRELFacilitiesandProducts.aspx