US Army Corps of Engineers®
Engineer Research and Development Center

CRREL Frost Effects Research Facility

Purpose

In the Frost Effects Research Facility at the Cold Regions Research and Engineering Laboratory, investigations can be conducted with full-scale construction equipment all year round under controlled conditions; the effects of moisture, low temperatures, and frost action on road and airfield pavements can be studied; and full-scale testing of buried pipes can be conducted to evaluate thermal effects in permafrost areas as well as in seasonally freezing and thawing environments. Soil dynamics, foundations in frozen soils, and off-road mobility can be examined under all conditions.

Specifications

The FERF is a 2,695-m^2 (29,000-ft^2) controlled-environment soils lab divided into bays that can be isolated for simultaneous testing. It contains a 55.5- by 22.8-m (182- by 75-ft) testing area that can be maintained down to –6.6°C (20°F). This area contains 12 large test basins with a built-in temperature range of 155°F — they can go as high as 49°C (120°F) and as low as –37°C (–35°F). Air temperatures can be maintained down to –7°C (20°C).

The FERF permits full-scale, controlled-environment tests year round.

The FERF delivers rapid solutions to a customer's problems. Soils may be frozen from the top down with refrigerated panels to simulate natural freezing at a rate of about 2.5 cm (1 in.) of frost per 24 hours or 0.9 m (36 in.) in a month (depending on the moisture in the soil), or freezing can be done from the sides and the bottom to create "permafrost" conditions. Pavements, base and sub-base courses, and buried utilities can be tested, and six to eight natural freeze/thaw cycles can be simulated in a single year. Large-scale, aboveground studies can also be conducted in the FERF, for example, with a tractor-trailer-mounted reverse osmosis water purification unit, or a 9- × 6- × 2.75-m high (30 × 20 × 9 ft), 405-ton block of concrete to test drilling in frozen rock.

The Heavy Vehicle Simulator is capable of 600 one-way passes per hour, or 14,000 passes in 24 hours. This adds up to 20 years of equivalent traffic in only 6 months. When projects are under way, real-time images of the HVS conducting pavement testing in the FERF can be viewed via a CRREL WebCam. Watch a video loop of the HVS in operation at http://www.crrel.usace.army.mil/welcome/facilities/images/HVS_CRREL.rm.

The Heavy Vehicle Simulator.

Benefits

The Frost Effects Research Facility totally eliminates the *if* factor in conducting controlled experiments. Full-scale testing avoids the inherent limitations of scale-model testing which just replicates real-life conditions; computer simulation, which is only as valid as the information that's entered or the program that runs it; and field testing, which is expensive and often unreliable.

Full-scale tests can be conducted under completely controllable, uniform conditions at any time of the year, running tests at or near scale, under predictable and repeatable conditions, for any length of time or number of repetitions. Freeze/thaw cycling, if needed, can be compressed, significantly shortening the total testing time. The same materials that will be encountered on site can be used, as it is standard procedure to import soils or other materials to ensure the reliability and validity of the results. And results from tests conducted in the FERF can of course be used to verify results already obtained from model tests and computer simulations.

The FERF offers other benefits to ERDC's customers:

- Full-scale aboveground testing of buildings and vehicles
- Service as a cooperative pavements research facility with the Federal Highway Administration, the Federal Aviation Administration, and the U.S. Air Force
- Evaluation of digging, ripping, and drilling equipment
- Study of mobility in thawing soil and soil erosion
- Pavements testing, utility systems, and large-scale testing.

Success Stories

Pavement surface condition sensors have been tested in the FERF and evaluated for their ability to sense frozen/dry, frozen/wet, thawing/dry, thawing/wet, normal/dry, and normal/wet conditions. The objective was to develop accurate sensors that can be installed in pavements to monitor changing environmental conditions remotely. As conditions deteriorate to freezing temperatures and condensation or precipitation, the information is used to send out maintenance vehicles to treat the pavement with chemicals before surface icing conditions develop or, once they develop, to apply necessary materials to return the surface to safe conditions.

The effects of subgrade moisture on a road's load-carrying capacity were evaluated in the FERF. Actual loading tests were conducted on identical 7.5-cm (3-in.) asphalt concrete pavements over 23 cm (9 in.) of crushed rock base courses, over various native soils or subgrades with varying moisture conditions. Based on the test results, a pavement design computer model can now be selected and validated that can be used worldwide. A pavement designer can enter the characteristics of locally available pavement, base course, and subgrade materials along with the site environmental conditions and expected traffic to optimize the layer thicknesses at that location, thereby saving precious resources and money.

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