1st INTERNATIONAL HVS WORKSHOP

SOUTH AFRICA

OCTOBER 7th – 8th, 2002
Dr. Vincent Janoo  
ERDC/CRREL  
72 Lyme Road  
Hanover, NH, USA 03755  
*Vincent.C.Janoo@erdc.usace.army.mil*  
603 646 4702/4207  
603 646 4843 (FAX)  
603 359 0402 (CELL)
US Army Cold Regions Research and Engineering Laboratory
Hanover, New Hampshire

US Army Corps of Engineers
Engineer Research and Development Center
CRREL Staff Profile

Staff Education Profile

- Bachelor: 33
- PhD: 56
- Master: 56

Total CRREL Staff: 196

- Engineers & Scientists: 112
- Technicians/aids: 58
- Administrative: 12
- Other Technical Support: 4
- Clerical: 8
- Wage Grade: 2

Registered Professional Engineers: 35
## Technical Staff Capabilities

<table>
<thead>
<tr>
<th>SCIENTISTS</th>
<th>ENGINEERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Scientist</td>
<td>Civil Engineers</td>
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<tr>
<td>Physicist</td>
<td>Foundations</td>
</tr>
<tr>
<td>Geophysicist</td>
<td>Hydraulics</td>
</tr>
<tr>
<td>Geologist</td>
<td>Pavements</td>
</tr>
<tr>
<td>Chemist</td>
<td>Environmental</td>
</tr>
<tr>
<td>Geochemist</td>
<td>Snow and Ice Mechanics</td>
</tr>
<tr>
<td>Meteorologist</td>
<td>Soil Mechanics</td>
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<tr>
<td>Hydrologist</td>
<td>Mechanical</td>
</tr>
<tr>
<td>Biologist</td>
<td>General</td>
</tr>
<tr>
<td>Glaciologist</td>
<td>Electrical</td>
</tr>
<tr>
<td>Geographer</td>
<td>Electronic</td>
</tr>
<tr>
<td>Agronomist</td>
<td>Materials</td>
</tr>
</tbody>
</table>
Mission Statement

Advance and apply cold regions science and engineering providing all-season solutions for the Army, DoD and the Nation AND ……. 
With respect to pavements, our focus is on the impact of moisture and/or temperature on pavement performance. We tend to focus on spring thaw issues but are not limited to this specific area.
Pavements Program

Customer Diversity

Air Force, DOT • FAA • USFS
States of AK, CA, NH, ME, MD, MN, NV, VT, WA, MT, RI, CT, ND, WI, OR, NE, IN, KS, FL, GA, TX

Dartmouth College
University of Alaska
University of Arizona
University of Cincinnati
Montana State University
University of New Hampshire
University of New Mexico
University of New Orleans
University of Vermont
University of Washington
University of California, Berkeley

Caterpillar, Inc.
Goodyear Tire & Rubber Company
Exxon Production Research Company
Textron
Castle Rock Consultants, Inc.
The Irving Company
American Society of Civil Engineers
Pavement Research Areas

Military

- Joint Rapid Airfield Construction
  - Rapid Stabilization
  - Remote Assessment of Airfields

Reimbursable

- Subgrade failure criteria
- Reinstatement of utility cuts
- Geosynthetic reinforcement of base course
- Seasonal monitoring of pavements
- Impact of asphalt modifiers in cold regions
- Impact of variable tire pressure in thawing soils
- Pavement sensor evaluation
- Consulting to various agencies
Frost Effects Research Facility

- 2,700 m² environmentally controlled building.
- Facility is 56 m long by 31 m wide.
- 12 test cells, 6.4 m wide.
  - 8 cells are 7.6 m long and 2.4 m deep.
  - 4 cells are 11.3 m long and 3.7 m deep.
- Cells can be made impermeable to simulate the raising and lowering of the water table.
- Ambient air temperature within the facility can be controlled from -4 °C to 24 °C with a ± 2 °C tolerance.
- The temperature can be further reduced or increased using surface panels (-32 °C to 49 °C).
Frost Effects Research Facility

- Accelerated testing
  - Load (HVS)
  - Climate
- Controlled environments
  - Temperatures: -37 to 49 °C
  - Water table
  - Freeze/thaw (6 cycles/year)
- Full-scale pavement sections
  - Surface course
  - Base and subgrade
- Test basins
  - Flexible, to 30 x 15 x 4 m
- Instrumentation
  - Temperature
  - Moisture
  - Stress
  - Strain
  - Profilometer
Heavy Vehicle Simulator

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
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<tbody>
<tr>
<td>Wheel Load</td>
<td>20 – 100 kN roadway</td>
</tr>
<tr>
<td></td>
<td>Up to 200 kN airfield</td>
</tr>
<tr>
<td>Test Wheel</td>
<td>Single, Dual or Aircraft</td>
</tr>
<tr>
<td>Tire Pressure</td>
<td>550 – 757 kPa on roads; up to 1450 kPa on airfields</td>
</tr>
<tr>
<td>Repetitions, Per Hour</td>
<td>600 (uni-directional)</td>
</tr>
<tr>
<td>Trafficked Length</td>
<td>Approximately 7 m</td>
</tr>
<tr>
<td>Trafficked Width</td>
<td>Variable up to 1.5 m</td>
</tr>
<tr>
<td>Trafficked Pattern</td>
<td>Variable</td>
</tr>
<tr>
<td>Power</td>
<td>Electric</td>
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</table>
Past Work

- Impact of freeze thaw on DOD airfield pavement structures.
- Rapid repair of cratered pavements during winter.
- Thermal and strain gradients in PCC pavement structures during freezing and thawing.
- Stabilization of thawing soils.
- Validation of SHRP thermal cracking specifications
- OTHERS
Current Work

- Assessment of geosynthetics for base course reinforcement (Janoo/Cortez).
- Subgrade failure criteria (Janoo/Cortez).
- Reinstatement of utility cuts (Janoo/Eaton).
- Impact of variable tire pressure on performance of thawing soils (M. Rollings).
- Stress and strain response in thawing soils (Janoo)
Subgrade Failure Criteria
• **Hypothesis**
  • *The subgrade failure criteria is a function of soil type and moisture content*

• **Study involved** the Danish Road Institute, Finnish VTT, FHWA, COE, Cornell University & Minnesota DOT
75 mm AC

229 mm Base

3 m Subgrade
INSTRUMENTATION

- emu gages
- oVITEL Moisture gages
- • • DYNATEST stress cells
- ◇ temperature sensors

N
Vertical strain (microstrain)

Load = 62.3 kN
Tire Pressure = 721 kPa
Subgrade (z = 533 mm)
Load = 80kN
Tire pressure = 690 kPa
N = 10000 passes

Dynamic strain (microstrain)

Time (sec)
N = 500 reps
Load = 62 kN
Tire pressure = 720 kPa
Engineer Research and Development Center
US Army Corps of Engineers

Longitudinal stress (kPa)

- Time (seconds)
- Longitudinal stress (kPa)
- z = 404 mm
- z = 762 mm

N = 50000 reps
Load = 62 kN
Tire pressure = 720 kPa
N = 50000 reps
Load = 62 kN
Tire pressure = 720 kPa
Transverse rut measurements

[Graph showing surface deformation vs. transverse distance for different load repetitions (N = 500, 5000, 51400, 149614)]
Longitudinal rut measurements

Surface rut depth (mm)

N = 500
N = 10000
N = 25000
N = 50000

703C2
REINSTATEMENT OF UTILITY CUTS
Funded through a consortium of utilities and municipalities.

**OBJECTIVE**

- Best practice for reinstatement of cuts to minimize performance of existing pavements.
- Joint project between CRREL and NRC of Canada
ACCELERATION/DECELERATION ZONES (1m x 1m)

NUMBER IN TEST WINDOW INDICATE SEQUENCE OF LOADING
- Heavy Vehicle Simulator (HVS)
- 40 kN load
- 690 kPa tire pressure
- 10,000 load repetitions, uni-directional
- Measured surface deformation at various locations and load reps
PRECUT INSTRUMENTATION
PRECUT INSTRUMENTATION

STRESS CELLS

STRAIN CELLS
### TRENCH

<table>
<thead>
<tr>
<th>PRECUT</th>
<th>RESTORED</th>
</tr>
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<tbody>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>AC</th>
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</thead>
<tbody>
<tr>
<td>granular base</td>
<td>granular base</td>
</tr>
<tr>
<td>sand subbase</td>
<td>sand subbase</td>
</tr>
<tr>
<td>subgrade</td>
<td>subgrade</td>
</tr>
<tr>
<td>Layer</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>AC</td>
<td></td>
</tr>
<tr>
<td>granular base</td>
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<tr>
<td>subgrade fill</td>
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<td>sand subbase</td>
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subgrade
BELLHOLE

<table>
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<tr>
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**Diagram:**
- **X-axis:** Depth (mm)
- **Y-axis:** Displacement (mm)
- **Legend:**
  - blue line: midcut (face)
  - orange dashed line: cut (face)
  - red triangle: restore (face)

**Labels:**
- Extension
- Compression

**Key Points:**
- The diagram shows the displacement and depth of different materials (AC, granular base, subgrade fill, sand subbase) under extension and compression forces.
BELLHOLE

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<td>sand subbase</td>
<td>subgrade</td>
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Displacement (mm)

Depth (mm)

EXTENSION  COMPRESSION

EXTENSION COMPRESSION

AWAY FROM FACE

- cut (away)
- restore (away)
- precut (away)
## STRESS MEASUREMENTS

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<tr>
<td>VERTICAL</td>
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<td>PRESSURE</td>
</tr>
<tr>
<td></td>
<td>(psi)</td>
<td>(kPa)</td>
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<tr>
<td>PRECUT</td>
<td>3.81</td>
<td>26.30</td>
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<tr>
<td>CUT</td>
<td>3.99</td>
<td>27.54</td>
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<td>3.69</td>
<td>25.44</td>
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<td></td>
<td>(psi)</td>
<td>(kPa)</td>
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<td>2.56</td>
<td>17.68</td>
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<td>(psi)</td>
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<td>21.46</td>
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STRESS-STRAIN RESPONSE DURING THAW
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US Army Corps of Engineers

Subgrade Modulus factor


Backcalculated
15 in
21 in

US Army Corps of Engineers
Engineer Research and Development Center
Preliminary Conclusions

- Observed thaw weakening of crushed base course layer. (RF = 0.33)
- Similar to that seen from FWD
- Observed reduction in subgrade = 0.20
- From FWD: RF = 0.5
- Length of thaw weakening predicted from FWD lower than that observed from measurements