

## Technical Dossier of the Cold In-Place Stabilized Pavement

Structural performance, freeze-thaw, heat, military acceptance, ecological harmlessness and carbon footprint.

Quebec, Canada · June 2026

Proudly made in Quebec



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LL-TEQ™ · TECHNICAL DOCUMENT

# Technical Dossier

The cold in-place stabilized pavement, from structure to carbon

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*Technical document. The engineering dossiers signed by the Engineer of Record are the official records and govern.*

The unconfined laboratory cylinder value is not the in-service performance: it is a floor that the confined layer exceeds.

## 3,705

PSI (25.5 MPa)

Maximum corrected compressive strength (UCS), unconfined cylinder per ASTM C39/C42, on crushed recycled aggregate.

## 1.78

mm of rutting

Maximum rut at 20,000 passes (Hamburg Wheel-Track, AASHTO T-324, 25 degrees submerged), or 14 % of the allowable threshold.

## 16

specimens

LL30 specimens tested over 7 years (2016 to 2023) in an AASHTO-accredited third-party laboratory, across 3 substrate categories.

**Why it matters.** In service, the LL30 layer is laterally confined by the surrounding treated material and cannot expand. The laboratory cylinder, however, is tested without confinement, under conditions that do not exist on the road. A pile of sand spreads out under your weight; the same sand in a rigid bucket carries far more. The sand has not changed, the confinement changes what it carries. In-service strength therefore exceeds the laboratory value.

### Real aircraft loads, measured in the field

## 2,470

C-17 passes

C-17 Globemaster at about 204 t, computed by PCASE 2.09 at Mocoron, Honduras (USAF AFSOC).

## 10,000+

KC-130J passes

KC-130J at about 79 t at ALZ Sandhill, 29 Palms; surface CBR greater than or equal to 60 (USMC, 2019).

## 100,000

MMLS cycles

Accelerated MMLS loading at 46 to 60 degrees, with no measurable deflection or rutting (Kamen Engineering).

### Structural watertightness

Hydraulic conductivity drops by about an order of magnitude, from  $6.0 \times 10^{-8}$  to  $5.9 \times 10^{-9}$  cm/s (ASTM D5084).

### Thermal stability

The rut stays at 1.33 mm at 25 degrees and 1.29 mm at 35 degrees: no softening in the heat, no hardening with age.

### Immediate bearing (IPI)

IPI of 200 to 335 depending on dosage after drying, or about 3 to 5 times the untreated reference (IPI 68).



ALZ Sandhill military airfield, 29 Palms: LL-TEQ layer as the final wearing surface under aircraft loads.

Nine pavements in real service, up to 172 freeze cycles per year, **no defects**, on a layer far thinner than in Quebec.

9	77	6,730	0
sites in real service	winters	freeze-thaw cycles	defects
<p><b>Benton Harbor (Michigan)</b> Municipal road, local</p> <p>9 winters · ≈ 770 cycles LL-TEQ 150 mm Quebec 550 to 950 mm</p> <p><b>0 freeze-thaw defects</b></p>	<p><b>Alexandria (Virginia)</b> Municipal road, local</p> <p>9 winters · ≈ 405 cycles LL-TEQ 150 mm Quebec 550 to 950 mm</p> <p><b>0 freeze-thaw defects</b></p>	<p><b>Rockford (Illinois)</b> Heavy haul, collector</p> <p>8 winters · ≈ 720 cycles LL-TEQ 150 mm Quebec 750 to 1,150 mm</p> <p><b>0 freeze-thaw defects</b></p>	
<p><b>Glenview (Illinois)</b> Park access, local</p> <p>8 winters · ≈ 573 cycles LL-TEQ 150 mm Quebec 550 to 950 mm</p> <p><b>0 freeze-thaw defects</b></p>	<p><b>East Chicago (Indiana)</b> Industrial corridor, arterial</p> <p>8 winters · ≈ 536 cycles LL-TEQ 150 mm Quebec 1,000 to 1,500 mm</p> <p><b>0 freeze-thaw defects</b></p>	<p><b>Elgin (Illinois)</b> Heavy haul, collector</p> <p>8 winters · ≈ 576 cycles LL-TEQ 150 mm Quebec 750 to 1,150 mm</p> <p><b>0 freeze-thaw defects</b></p>	
<p><b>Bridgeport (California)</b> Military airstrip, arterial</p> <p>10 winters · ≈ 1,720 cycles LL-TEQ 200 mm Quebec 1,000 to 1,500 mm</p> <p><b>0 freeze-thaw defects</b></p>	<p><b>Big Bear Lake (California)</b> Mountain access, local</p> <p>7 winters · ≈ 1,070 cycles LL-TEQ 150 mm Quebec 550 to 950 mm</p> <p><b>0 freeze-thaw defects</b></p>	<p><b>Bessemer (Alabama)</b> Municipal road, local</p> <p>10 winters · ≈ 360 cycles LL-TEQ 150 mm Quebec 550 to 950 mm</p> <p><b>0 freeze-thaw defects</b></p>	

The six freeze-thaw defects sought at every site, all absent

<b>Longitudinal and transverse cracks</b>	Thermal shrinkage of the asphalt matrix over the cycles.
<b>Alligator cracking</b>	Crocodile-skin fatigue, amplified by freeze-thaw of the base.
<b>Frost heave</b>	Ice lenses formed in a frost-susceptible underlying soil.
<b>Slippage cracking</b>	Debonding of an overlaid surface course.
<b>Pothole</b>	Ejection of material from cracks, under water and frost.
<b>Rutting</b>	Permanent deformation in the wheel paths during thaw.

Climate benchmark, Montreal: about 75 freeze-thaw cycles per year (Köppen Dfb); five of the nine sites exceed that rate. Equivalent Quebec thickness: 550 to 1,500 mm depending on the road category, versus 150 mm for LL-TEQ (200 mm at Bridgeport).

Source: Engineering dossier PRV-02, Freeze-thaw performance, Mark D. Hardy, P.E., Hardy Engineering.

Bitumen fails because it melts; LL-TEQ does not melt

Bitumen fails because it melts. LL-TEQ, by contrast, does not melt.

# 926

degrees (1,700 °F)

The heat of an F-35B jet on the ground, to which an LL-TEQ layer was subjected in service.

# 1 to 3

mm

The only observed effect, a surface blackening; structure and bearing capacity intact.

# 15x

of margin

926 degrees is about 15 times the summer peak of a Quebec pavement (50 to 60 degrees).

**Why it holds.** Ordinary hot-mix (asphalt) fails because of its binder, bitumen, which softens as low as 45 to 65 degrees then melts. LL-TEQ does not melt: its polymer binder does not soften, and nearly 98 % of the layer is mineral, inert at these temperatures. Under extreme heat, only the surface chars over 1 to 3 mm and forms a shield, like an atmospheric re-entry shield; beneath it, the material stays cool and the structure holds.

Observed in real service, under the jet of an F-35B

# Sept. 2021

F-35B vertical landings at Twentynine Palms (USMC, California).

# 8 inches

LL-TEQ layer on native soil, in the direct impact zone of the jet.

# 0

Cracks, deformation or loss of bearing; only a 1 to 3 mm blackening.

#### Does not melt

Non-thermoplastic polymer binder and a nearly 98 % mineral skeleton, inert at the temperatures involved.

#### Surface shield

The layer chars over 1 to 3 mm and protects what is beneath, which stays cool; the structure is not affected.

#### Enormous margin

A summer pavement caps out around 60 degrees, a vehicle fire around 600 to 900 degrees: LL-TEQ withstands well beyond.



The exhaust jet of an F-35B in vertical landing strikes the ground, at 926 degrees per the reference standard.

Source: Engineering dossier PRV-03, Heat resistance, Mark D. Hardy, P.E., Hardy Engineering.

The LL-TEQ system has been deployed and certified as the final wearing surface under military aircraft loads: what carries the heaviest carries the lightest.

# 20

### military sites

Documented military and government deployments, across 14 countries and 5 continents, as a wearing surface and structural layer.

# 23,847

### C-130 passes

Certified allowable-passes rating at Mocoron, Honduras (USAF AFSOC) under C-130J at about 70 t, computed by PCASE 2.09.

# 2,470

### C-17 passes

Certified allowable-passes rating at Mocoron under C-17 Globemaster at about 204 t (evaluation load).

**What it proves.** The allowable-passes ratings are not laboratory projections: they derive from CBR measured by DCP in the field, processed by PCASE 2.09, the official USACE / ERDC tool. They were certified by named military authorities, the USAF AFSOC and the USMC. The military envelope bounds ordinary road use from above on every axis: load, speed and surface conditions.

### Certified under the US military pavement standards framework

# 10,000+

### KC-130J passes

ALZ Sandhill, Twentynine Palms: USMC-certified rating (2019), with a surface CBR of 60 and above.

# 36

### Cherry Point CBR

USMC comparative test (2017) under MTRV truck at about 18 t: OPSDIRT at CBR 36 versus 17.5 for the competitor, with no spalling.

# 265,000

### kg (C-17)

Maximum takeoff weight of the C-17 received in real service at Bridgeport on an LL-TEQ layer of about 200 mm.

#### Mocoron, Honduras (2015)

Runway evaluated by 28 DCP readings; PCASE ratings certified by USAF AFSOC for C-17 and C-130. Surface CBR 30.9.

#### N'Djamena, Chad (2016)

Taxiway and apron built under US Air Force specification for Flintlock 17, review signed by a P.E.

#### 29 Palms, expeditionary airstrip (2024)

About 35,000 m<sup>2</sup> placed in 4 days, at 100 % native soil with a cold recycler, USMC supervision.



*Evaluated under PCASE 2.09, UFC 3-260 and ETL 02-19. Project-by-project sizing remains the responsibility of the design engineer.*

**Source:** Engineering dossier PRV-04, Military acceptance and in-service performance, Mark D. Hardy, engineer (PE 36538), Hardy Engineering.

The water that leaves the road **does not pollute**: poured undiluted on living organisms, it does not kill them, and the sealed layer keeps water from carrying anything down to the soil and the water table.

# 0

## toxic mortality

No significant toxic mortality among the organisms exposed to the road runoff.

# 100 %

## pure runoff

Tested undiluted, at the highest possible concentration, not a softened version.

# 10 times

## less permeable

Water passes through the treated layer ten times less than through bare soil, so nothing migrates to the soil or the water table.

**Measured, not guessed.** Rather than judging the material by its ingredient list, rainwater run off the road was poured, pure and undiluted, onto sentinel aquatic organisms. After 48 hours, they were living as well as in clean laboratory water.

## Recognized by US federal authorities

# USFWS

Approved use in protected-species habitat (Alabama beach mouse).

# NEPA

Categorical exclusion granted, with no exceptional circumstances (Sierra Army Depot).

# EPA

Official test methods, accredited independent laboratory.

### Proven on living organisms

Pure road water was poured on sensitive organisms, and they survived. Not a prediction drawn from a recipe, a direct measurement.

### Nothing migrates

The hardened layer is almost impermeable. Water does not flow through it and carries nothing down to the soil or the water table beneath the road.

### Water-based, not petroleum

A water-based emulsion binds the soil in place, without the dark petroleum-derived bitumen, without any listed carcinogen, not classified as hazardous.

**Source:** Dossier PRV-05, Ecological harmlessness. Acute toxicity bioassay on runoff (WET): Coastal Bioanalysts, Inc., Peter F. De Lisle, Ph.D., NELAP/TNI-accredited laboratory. EPA Methods 2000.0 and 2002.0.

For the same road, LL-TEQ weighs **nearly six times less** in carbon than hot-mix asphalt, compared layer by layer on a real Quebec Ministry of Transport structure.

# 179

**fewer cars**

Converting 1 km of hot-mix asphalt to LL-TEQ is equivalent to taking about 179 gasoline cars off the road for a year.

# 320 t

**less CO<sub>2</sub>**

Per km of road, from day 1: about 68 t for LL-TEQ versus 388 t for hot-mix asphalt.

# 7 times

**thinner**

150 mm of in-place stabilized soil instead of 1,080 mm of conventional structure.

**Compared at equal function.** The two pavements do the same job on the same highway. The calculation is even conservative: LL-TEQ is counted in full, manufactured, placed and transported, whereas hot-mix asphalt is counted without its placement, for lack of public data. The real gap therefore leans even further in favor of LL-TEQ.

## Carbon per kilometer of road, in tonnes CO<sub>2</sub>e

For 1 km of two lanes (7,000 m<sup>2</sup>), at day 1, transport included.



And the gap widens: about 203 t versus 970 t per km over 40 years, maintenance and rehabilitation included.

### Less material

150 mm of soil treated in place rather than 1,080 mm of imported stone and hot-mix asphalt, so far less to extract, manufacture and truck.

### Cold-placed

No plant heating bitumen and aggregates to high temperature, the emulsion is spread at ambient temperature.

### Durable

Surfaces in service since 2014 with no documented structural rehabilitation. Every rehabilitation avoided means tonnes of carbon less.

**Source:** Dossier PRV-06, Comparative carbon footprint. Reference structure: Volume II of the Quebec Ministry of Transport. Public emission factors: NAPA (hot-mix asphalt), PlasticsEurope (polymer), EPA (transport and car equivalence). Order-of-magnitude comparison.

**Process 1: full pavement, from milling to sealing**

Integration of LL30 through the full project thickness (50 to 200 mm), compacted to 95 %+, followed by an LL25 surface seal. The grader follows the stabilizer directly; the sequence is milling, shaping, first compaction, finish grading, final compaction, sealing.



1

**Milling and integration**

Integrate LL30 with the stabilizer (cold recycler) to the target depth, 50 to 200 mm, over a stable base of asphalt, native soil or gravel.



2

**Shaping**

The grader follows directly behind the stabilizer and shapes to the geometry set by the project.



3

**First compaction**

Steel double-drum roller; protects the surface. In case of rain, push to 95 %+ without waiting.



4

**Finish grading**

Grader pass for the final surface adjustment before final compaction.



5

**Final compaction**

Compact in cross passes to 95 %+. Verification by the accredited contractor.



6

**LL25 sealing**

After 2 h, apply LL25 from the tanker truck's rear spray bar to uniform surface saturation.

**Conditions and control points.** Unfrozen and stable base, ambient and base temperatures above 5 °C. Do not work in the rain. OMC checked every 25 m behind the stabilizer. Final compaction to 95 %+ in cross passes. A 2 h delay after final compaction before sealing. Cure by evaporation, minimum 12 h; reopening when the surface is no longer tacky to the touch, at the judgment of the accredited contractor.

## Process 2: LL25 surface seal alone on existing asphalt

LL25 is a water-based polymeric binder applied at the surface. It reduces water penetration and limits the effects of asphalt aging; primary use, protecting and extending the service life of asphalt surfaces. It also applies directly on native soil or gravel, to seal and bind the surface where there is no asphalt. Surface penetration of about 20 mm. Unfrozen base, temperature above 5 °C.



*Distributor tanker truck with calibrated spray bar.*

1

Inspect and validate the base stability; clean, remove contaminants, correct major defects. On asphalt, the surface must be dry.

2

Spray LL25 uniformly with the calibrated spray bar (tanker truck or distributor).

3

Apply additional passes to uniform surface saturation, depending on the base absorption.

4

Allow to cure undisturbed: at least 3 h without rain, no traffic before the surface sets.

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**Reference:** Document prepared by LL-TEQ. Ref.: TEQ-01 (pavement process) and TEQ-20 (LL25 Technical Manual, Rev. B). The sizing and acceptance of the work fall to the project designer.

The repair becomes a continuous layer again, not a joint that fails

### No potholes



Ordinary asphalt holes over in spring. An LL-TEQ pavement does not hole over: **no water, no crack, no pothole.**

# 10x

**less permeable**

Hydraulic conductivity lowered by an order of magnitude (ASTM D5084). Water does not penetrate.

# 6,730

**freeze-thaw cycles**

Endured across 9 pavements in service, 77 winters, with no defect attributable to frost (ASTM D6433).

# Monolithic

**jointless**

Continuous and ductile layer: no crack or joint where a hole could start.

**Why it does not happen.** A pothole comes from a chain: water enters through a crack, freezes and thaws, breaks up the base, traffic tears out the piece. LL-TEQ breaks that chain: no water entering, no crack to start it, no frost damage.

### Trench reinstatement



*Utility trench reclosed: the repair blends into the pavement, while the old asphalt cracks around it.*

The trench becomes a continuous layer again, not a joint that eventually fails: **reclosed without dowels, with ordinary road equipment.**

# 0

**dowels**

Continuous and monolithic LL30 layer: no anchor bars, unlike concrete.

# 2x

**more resistant**

LL30 compressive strength (1,625 PSI) more than double that of Portland-cement-stabilized soil (ASTM C39/C42).

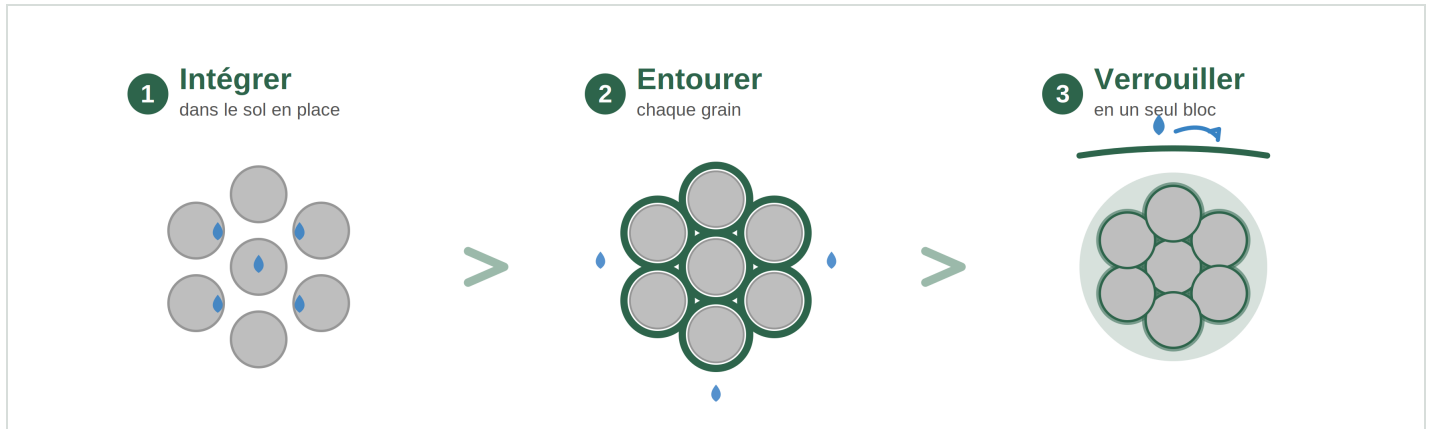
# C-17

**loads accepted**

The same continuous LL30 layer, without dowels, accepted under military aircraft loads (PCASE 2.09).

LL-TEQ keeps water from entering the soil, **everywhere in the structure**, not just at the surface. That is what ends the freeze-thaw cycle that bursts our roads from the inside.

### How it works, in three steps



No added materials: the soil already in place is transformed into a sealed matrix. Water can no longer enter, even under full submersion.

**Rigid, but with memory.** Like rubber that is stretched and springs back to shape, the polymer combines hard segments that carry the load and soft segments that absorb frost and pressure variations. The treated soil stays solid as a block, with just enough flexibility not to crack after years of freeze-thaw.

### A product that changes state at the right moment

#### Thick

Before application: dense and stable, it stays in place, it does not run.

#### Fluid

During mixing and compaction: it works its way between the grains and surrounds every particle.

#### Rigid

After compaction: it sets and locks the entire structure.

#### High bearing capacity

The load spreads through the whole treated volume. No weak point, no zone that sags first.

#### Fatigue resistance

The structure withstands repeated passes of trucks and heavy equipment without degradation.

#### Water resistance

It stays stable even in wet conditions or under full submersion.

**Source:** LL-TEQ dossier, how the process works. Internal document, unsigned. The measured performance is detailed in dossiers PRV-01 (structural performance) and PRV-02 (freeze-thaw).

Born in Chicago, proven in winters as harsh as ours, LANDLOCK™'s technology has since traveled all the way to the US border wall.

# 3

## founders in Chicago

Technology invented by the three founders of LANDLOCK™, including brothers Jon and Jay Walley, with Mike Kotorowski.

# -39 °C

## and it holds

Pavements proven in Illinois's polar-vortex winters, harsher than ours, with no frost heave.

# 250,000

## sq yd at the wall

Heavy roads stabilized for the US border wall, in desert soil (2020).

**The same climate as ours.** Several reference pavements are in Chicago and its region, in fine soils comparable to the clays of the St. Lawrence Lowlands, under polar-vortex winters. The East Chicago arterial road has withstood more than a million heavy-axle passes on only 150 mm. What holds there holds here.

## Where the technology comes from

### LANDLOCK™

The polymeric soil stabilization technology, the origin of everything.

### OPSDIRT

Its military subsidiary, which carried the technology into theaters of operation.

### LL-TEQ

The exclusive distributor in Quebec and Canada, adapted to our climate.

#### Named by the military

The US Army Corps of Engineers named OPS-DIRT, LANDLOCK™'s product, in the Arizona border-wall specification (2019).

#### Proven everywhere

20 military sites across 14 countries, from the deserts of Arizona to Chad, Niger and Kuwait, certified for thousands of heavy-aircraft passes.

#### The same product here

LL30 and LL25 are the military products OPS30 and OPS25: the exact material, distributed in Quebec by LL-TEQ.

**Source:** LL-TEQ dossier. Founders and identity: LANDLOCK™ identity statement (Chicago). Winters and East Chicago: freeze-thaw dossier PRV-02. Border wall: US Army Corps of Engineers, solicitation W912PL19R0093 (2019). Military deployments: dossier PRV-04.

A single system, cold-formed in place, that transforms the soil into one structure: **structural, durable, safe and far lower in carbon.**

# 926

**degrees withstood**

F-35B jet on the ground: 1 to 3 mm of blackening, structure and bearing intact (section 03).

# 6,730

**freeze-thaw cycles**

Across 9 sites and 77 winters in real service, zero freeze-thaw defects observed (section 02).

# 6×

**less carbon**

About 9.6 versus 55 kg CO<sub>2</sub>e/m<sup>2</sup> against hot-mix asphalt, transport included (section 06).

The same integration meets every requirement

# 25.5 MPa

**in compression**

Measured strength (UCS); rut at 14 % of the allowable threshold, bearing 3 to 5 times the reference (section 01).

# 14

**countries, 5 continents**

20 military sites certified up to the C-17 (204 t) and the F-35B (section 04).

# 0

**toxic mortality**

100 % survival of organisms exposed to the undiluted road runoff (section 05).

**The common thread.** The performance does not come from a layer laid over the soil, but from the soil itself transformed into a cohesive, non-thermoplastic and watertight matrix. The same integration explains the bearing capacity under aircraft loads, the resistance to Quebec freeze-thaw, the resistance to extreme heat, the measured ecological harmlessness and the reduced carbon footprint.

What the dossier establishes, and its limitations

#### Established by the data

Strengths, ruts, freeze-thaw cycles, military allowable-passes ratings and toxicity tests come from referenced tests and in-service observations.

#### Acknowledged bounds

CHAUSSÉE 2 resilient modulus (LC 22-400), chronic harmlessness and TCLP analysis remain to be produced or accepted by the regulator.

#### Design responsibility

The sizing and acceptance of a specific work fall to the design engineer under the applicable jurisdiction.

# LL-TEQ



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