

Extending the Season for Concrete Construction and Repair

Charles Korhonen

*Research Civil Engineer
Cold Regions Research and Engineering Laboratory
72 Lyme Rd
Hanover, NH 03755*

NESMEA

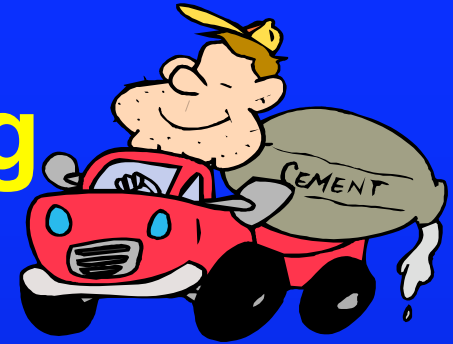
Northeastern States Materials Engineers' Association

October 19-20, 2004, Portsmouth, NH



U.S. Army Cold Regions Research
and Engineering Laboratory
(CRREL)

Winter Concreting (review)



Current Practice

- Not changed since the 1930s
- Thaw substrate
- Pre-heat materials
- Use insulation and heated enclosures

1990s

- Demonstrated antifreeze admixtures

Problem

- No acceptance standard for antifreeze admixtures.
 - * Tort Liability
 - * Market Size
 - * Inertia
- No single commercial admixture significantly lowers the freezing point of fresh concrete.

Solution

- Combine Off-the Shelf Admixtures
 - Already Meet Standards
 - Familiar & Available
 - No Limit on the # of Admixtures



POOLED-FUND STUDY

October 2000 – October 2003

(ID, MI, MT, NH, NY, PA, UT, VT, WI, WY)

FHWA TPF 5-(003)

Objective: develop concrete that can fully cure at below freezing temperatures

Product: tools to design, mix, place, and cure concrete in below-freezing weather

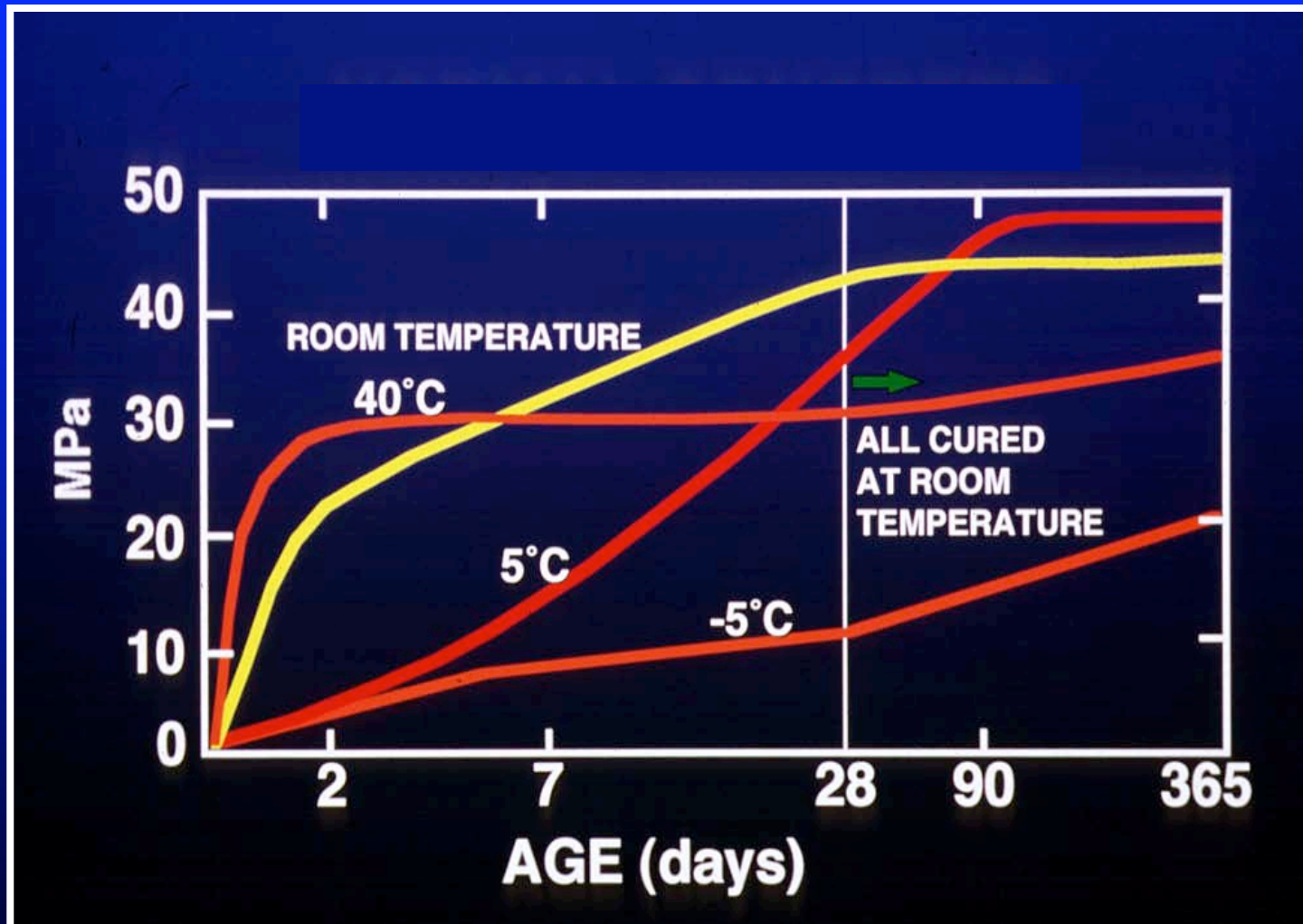


US Army Corps
of Engineers ®
US Army Cold Regions
Research and Engineering Laboratory

Extending the Season for Concrete Construction and Repair



How Normal Concrete Performs

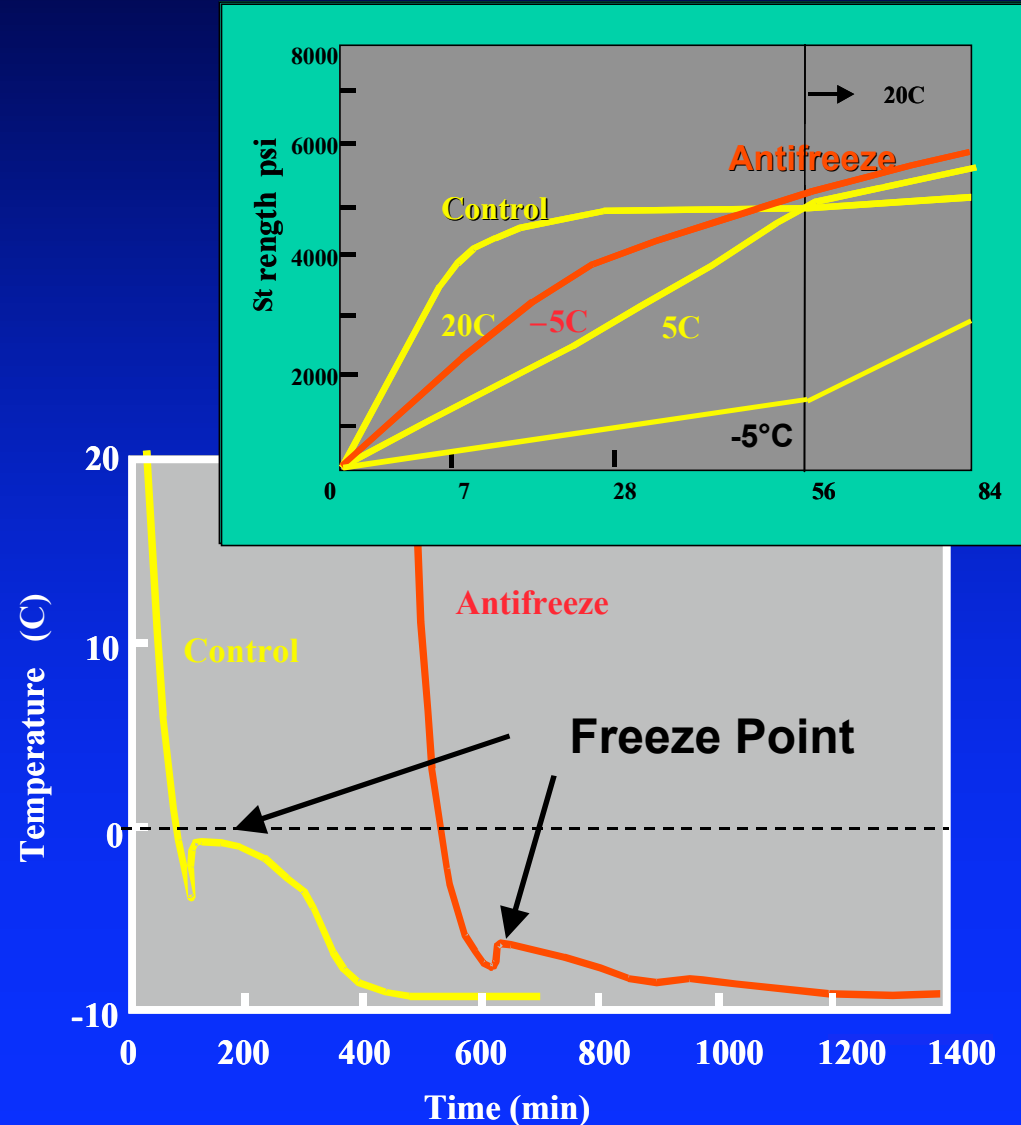


How Antifreeze Admixtures Work

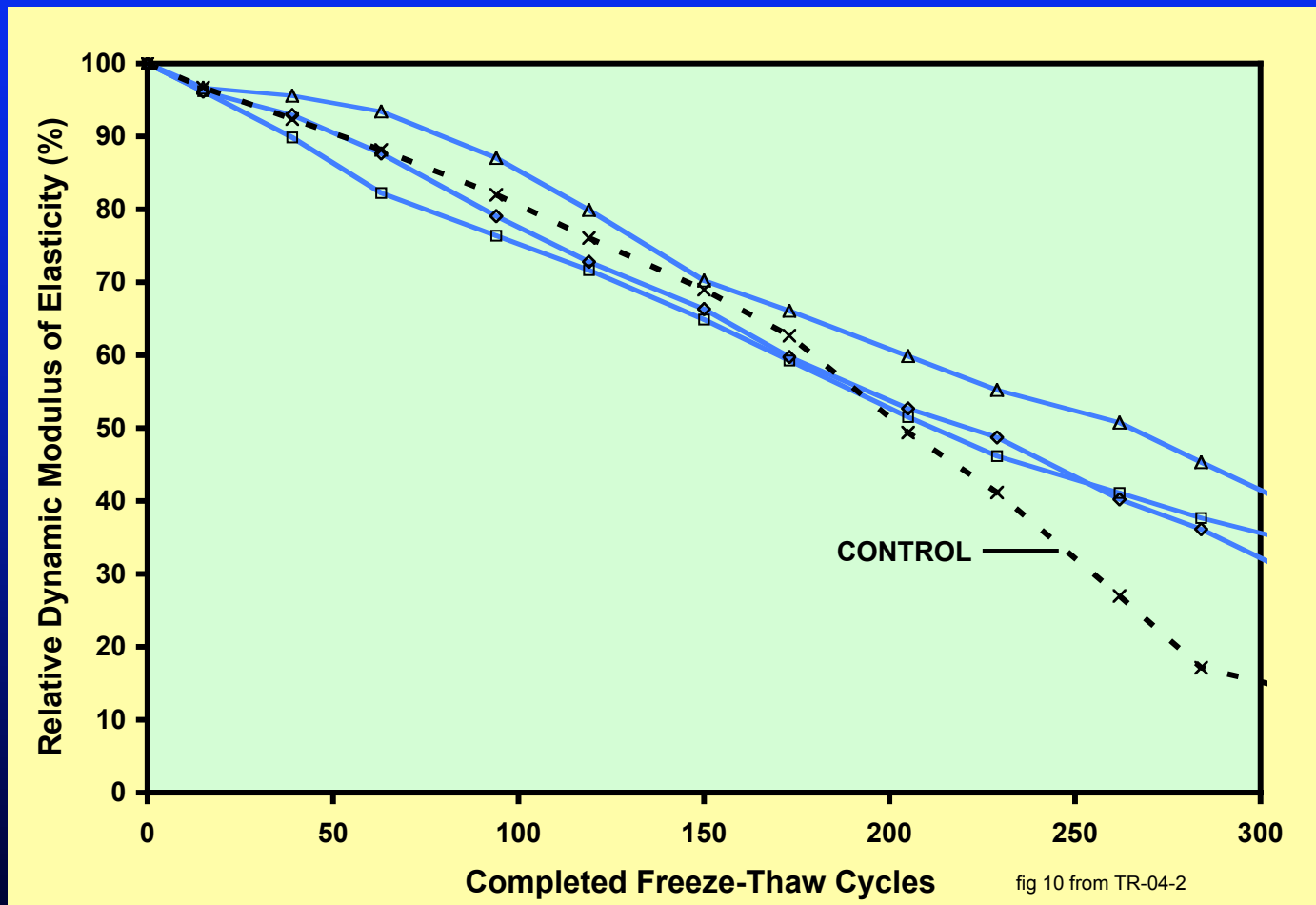
Combine admixtures to:

- Depress the freezing point
- Accelerate the hydration rate of cement

“Antifreeze Concrete”



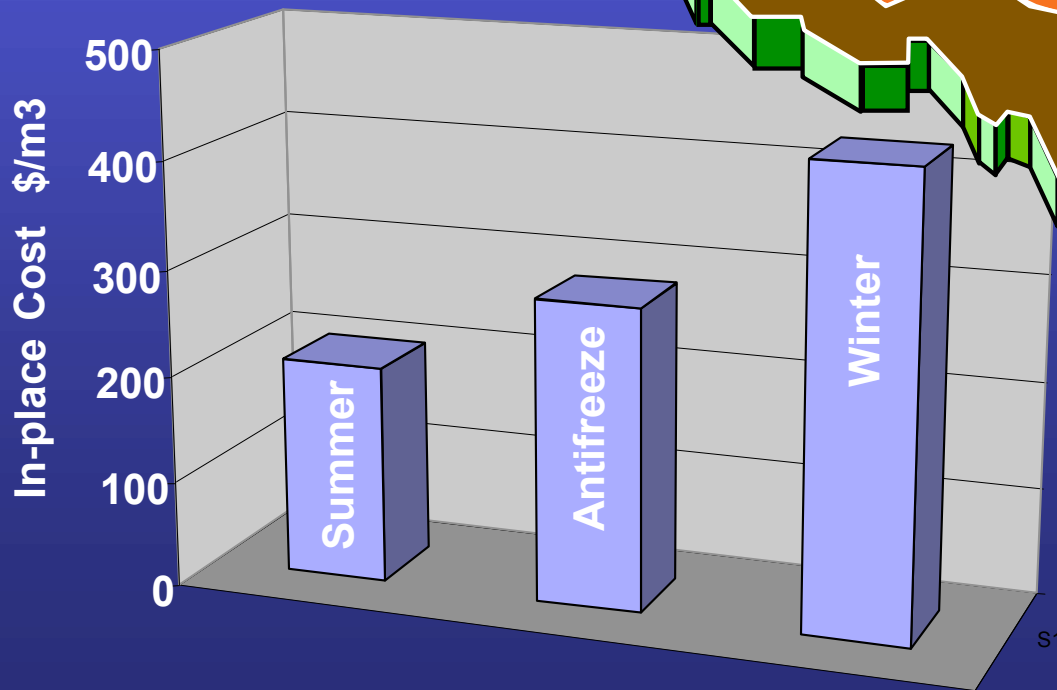
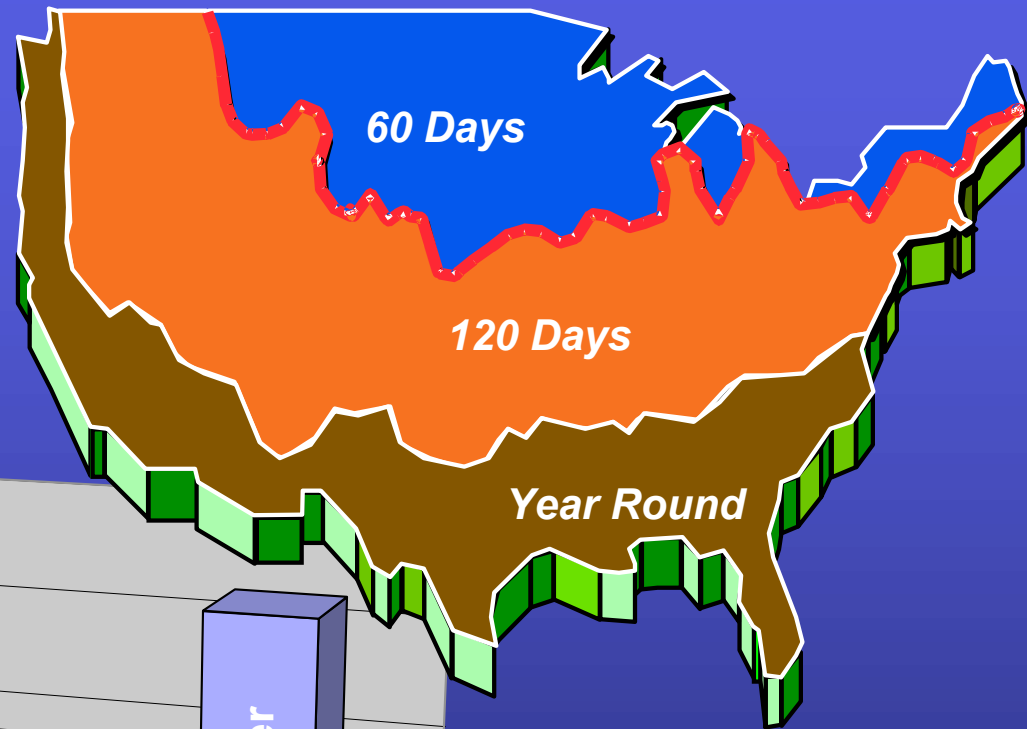
Admixtures do not reduce concrete's freeze-thaw durability



ANTIFREEZE ADMIXTURES: Cut Time & Cost

-5°C Capability

- 1/3 less cost
- Extends the season



Field Tested

FHWA Study

Littleton, NH	10 Dec '01	Bridge Curbing
Rhineland, WI	27 Feb '02	Pavement
North Woodstock, NH	12 Dec '02	Footing
West Lebanon, NH	18 Dec '02	Bridge Curbing
Concord, NH	14 Feb '03	Sidewalk

Others

New York, NY	18 Feb '04	Streets & Sidewalks
Grand Forks AFB, ND	23 Feb '04	Airfield slab

CASE STUDY

Bridge Curbing, W. Lebanon, NH
18 December 2002



Preconstruction Trial Batches

Adjustments Needed:

- Workability
 - * Cements Vary Widely
 - * Batching Plant Setups Differ
- Zero in on freezing point
 - * Agg. Moisture Varies
- Optimize Batch Sequence
 - * All at mixing plant
 - * Some at plant, rest at job
 - * All at job



BATCHING

Ready-Mix Plant

Ingredient	Amount
Cement	392 kg/m ³
Aggregate	1083 kg/m ³
Sand	804 kg/m ³
AEA	77 ml/m ³
Type A	584 ml/100kg
Cor. Inh.	30 L/m ³
Type E	5.87 L/100kg
Type E dosed but not mixed until truck arrived at jobsite	
W/C	0.37

Air Content 8.0%

Slump 200mm



10:15 A.M
-12°C

PLACING & FINISHING



Traffic Control



CURING

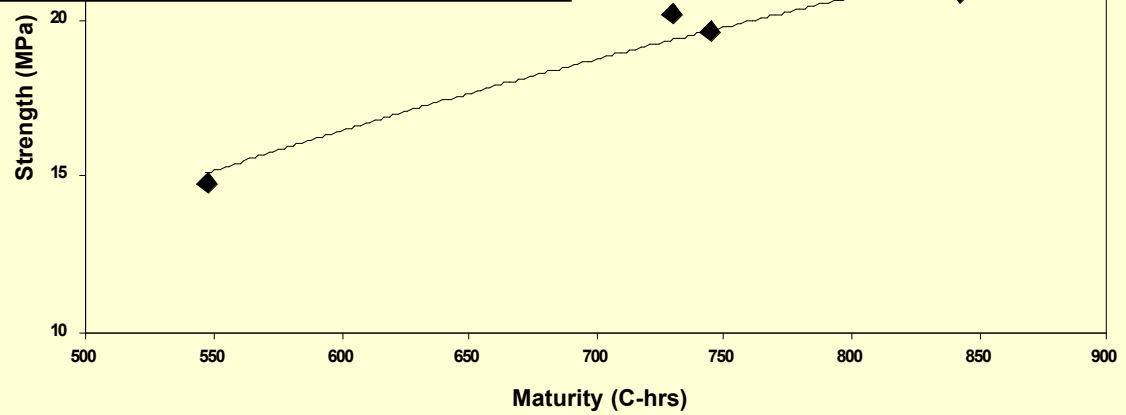
... but for how long?





Maturity

Fast-Track

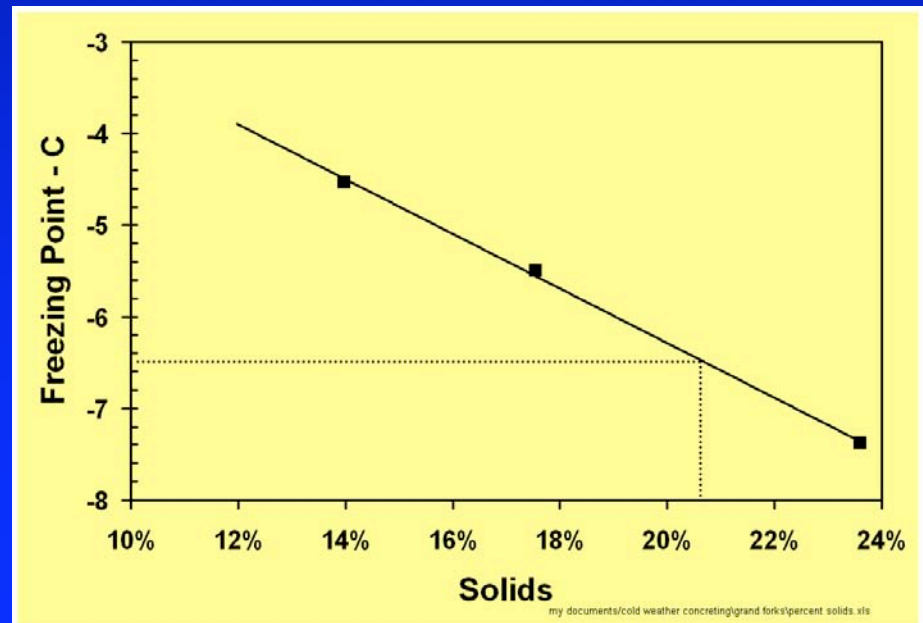
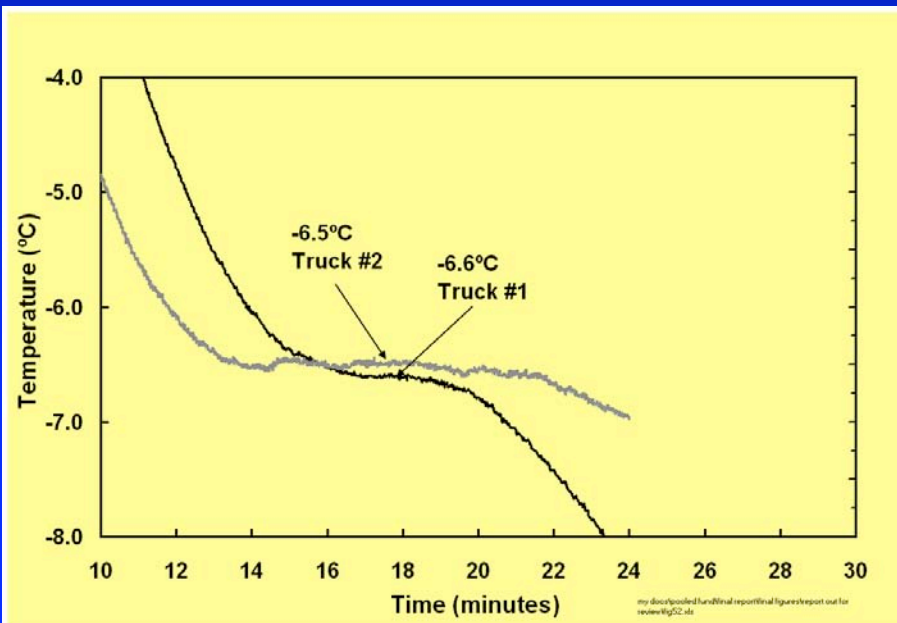




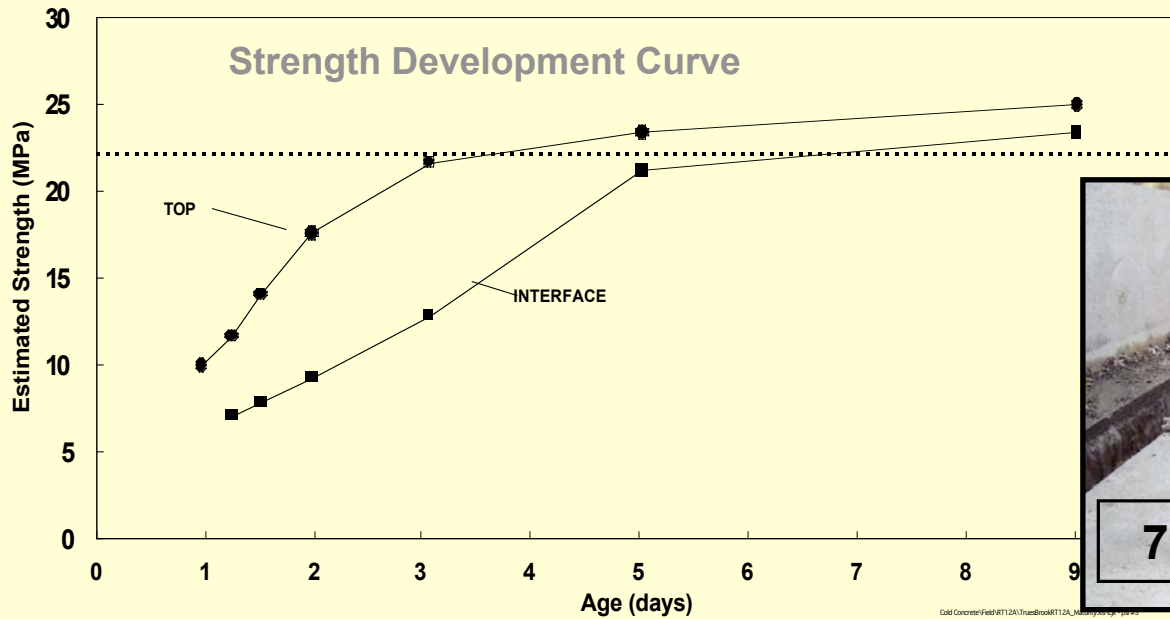
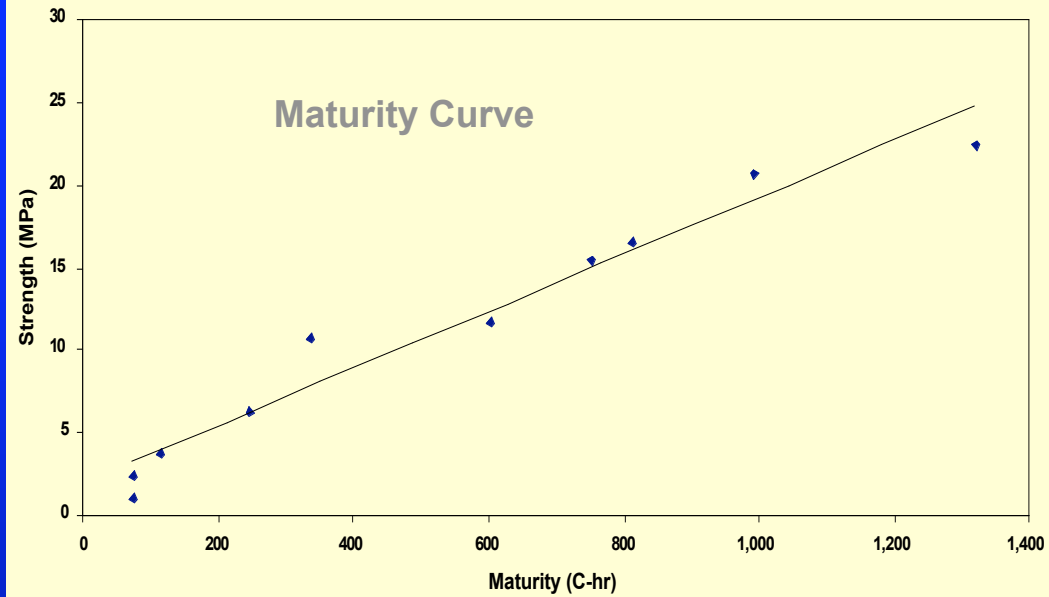
Measuring the Freezing Point

- Quality Assurance
- Back-calculate water/cement Ratio (Critical to Strength)

Is it good concrete?



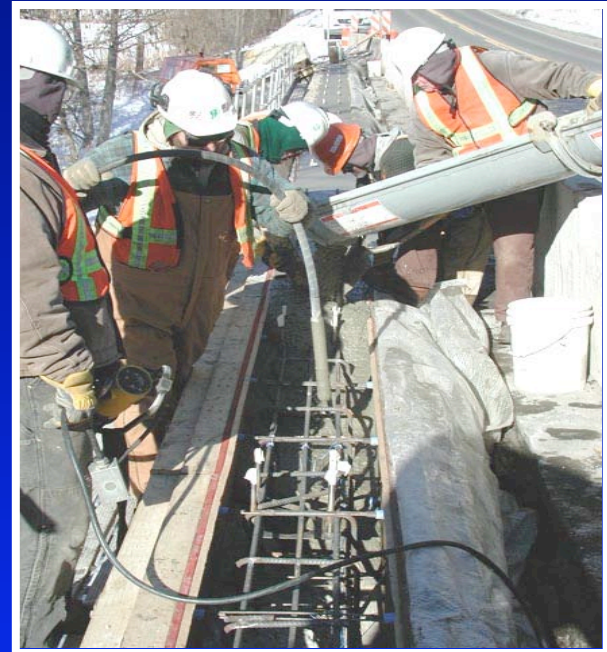
Actual Performance



Cost Comparison

Trues Brook, West Lebanon, NH

18 Dec '02



Erect Shelter: 96 mhr

Dismantle: 36 mhr

β Heat Shelter: 364 gal LP

Materials: 48 ea – 2x4x8
120 m – 1x8 pine
120 m – strapping
2 rolls – poly

Heat = \$748.47

β Admixture #1 = \$58.69/m³

β Admixture #2 = \$3.52/m³

β Admixture #3 = \$52.34/m³

Admixtures = \$700.64

... a chemical substitute for heat.

The Product

FHWA Pooled-Fund Study
TPF-5(003)



<http://www.crrel.usace.army.mil/concrete>



... developed an antifreeze technology that produces concrete that can fully cure while its internal temperature is below freezing, and that is as strong and durable as normal concrete cured during the summer.

What We Still Don't Know

Phase I – Establishing the Technology

“... demonstrated the practicality of antifreeze admixtures”

Phase II – Determining Engineering Parameters

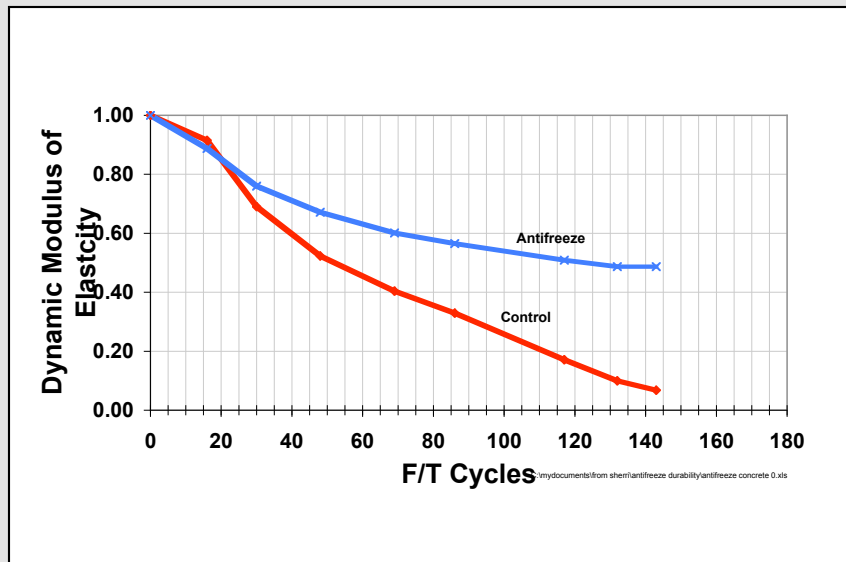
Enhanced Durability

Thermal Safety

Quality Assurance Tools

Other Cements

Phase II: Enhanced Freeze- Thaw Durability



Objective: The freeze-thaw durability of concrete seems to improve whenever high doses of chemical admixtures are used. This needs to be investigated.

SP&R Pooled-Fund Study TPF-5(075)

Extending the Season for
Concrete Construction and Repair
Defining Engineering Parameters

Phase II
Continuation of TPF-5(003)



US Army Corps
of Engineers®
ERDC



US Army Cold Regions
Research and Engineering
Laboratory

Extending the Season for Concrete Construction and Repair

Charles Korhonen

Charles.J.Korhonen@erdc.usace.army.mil

<http://www.crrel.usace.army.mil/concrete>



US Army Corps
of Engineers

Engineer Research & Development Center
Cold Regions Research & Engineering Laboratory