Colorado Ready Mixed Concrete Association

COLD WEATHER CONCRETE PRACTICES

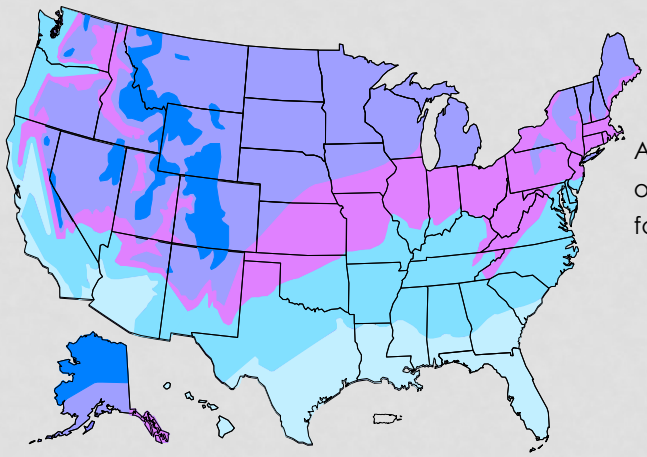
CRMCA SOUTHERN MARKETING

ACI DEFINITION OF COLD WEATHER

Cold Weather - A period when, for more than 3 consecutive days, the following conditions exist:

- **The Average daily air temperature is less than 40 °F (5 °C), and**
- **The air temperature is not greater than 50 °F (10 °C) for more than one-half of any 24 hour period.**

U.S. FREEZE / THAW ZONE MAP



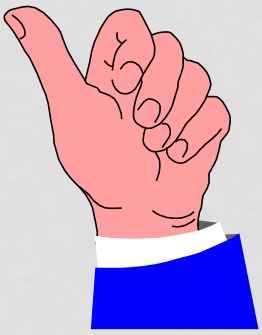
Setting Time of Concrete at Various Temperatures

Temperature, °F	Approx. Setting Time, hrs.
70	6
60	8
50	11
40	14
32	Concrete Freezes

CONCRETE FREEZES!

Effect of Early Freezing

Rule of Thumb



A 10 degree drop in concrete temperature will DELAY set time by approximately
2 – 2 ½ hours

Extended Concrete Setting Times

Increased Contractor Labor Costs

OBJECTIVES OF SUCCESSFUL COLD WEATHER CONCRETING

- Prevent damage to concrete due to freezing at early stages
- Assure that the concrete develops the required strength for safe removal of forms
- Maintain curing conditions that foster normal strength development
- Limit rapid temperature changes
- Provide protection consistent with the intended serviceability of the structure

What Can We Influence

- Materials
- Mix Design
- Placement Conditions
- Curing conditions and length of time
- Protection

Materials & Mix Design

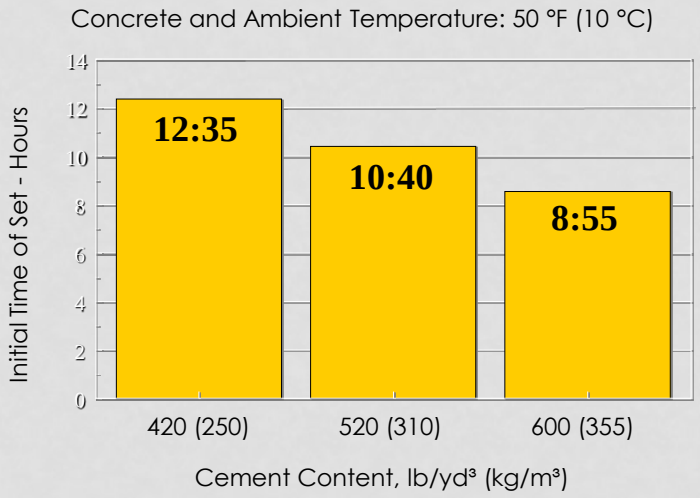
- GOAL is to ACCELERATE and INCREASE Maximum Temperature
- Provide concrete with predictable setting times
- Maintain Air entrainment and workability
- Minimize Plastic and Drying shrinkage

Cold Weather Concreting (Producer)

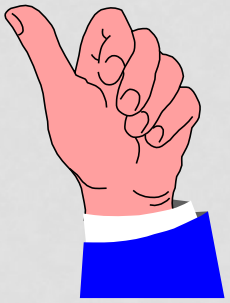
Speed up the early hydration (heat gain) of concrete can be obtained by using one or more of the following:

- Additional portland cement
- Use Type III Cement
- Hot water
- Heat Aggregate
- Use of calcium chloride
- Use of a non-chloride accelerating admixture

Effect of Cement Content on Setting Time Performance



Rule of Thumb

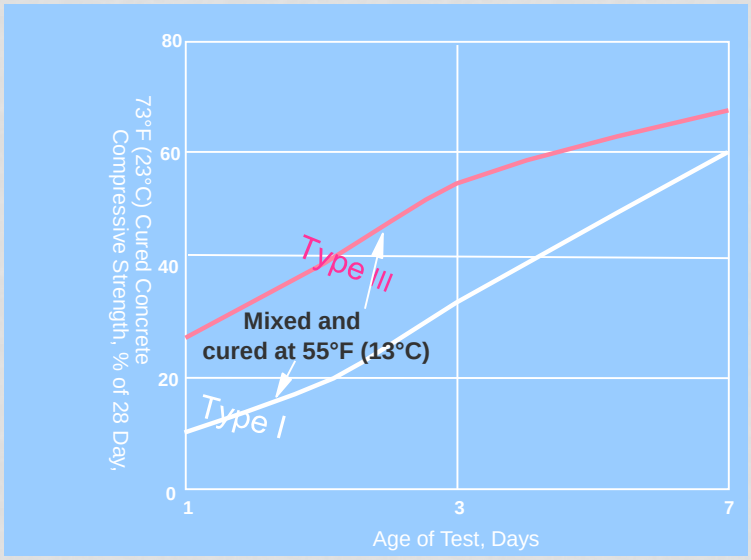


An increase of 1 sack of cement, will improve the set time by about 1 hour

Why?

Lower unit water content

Early Age Compressive Strength for Type I and Type III Cement



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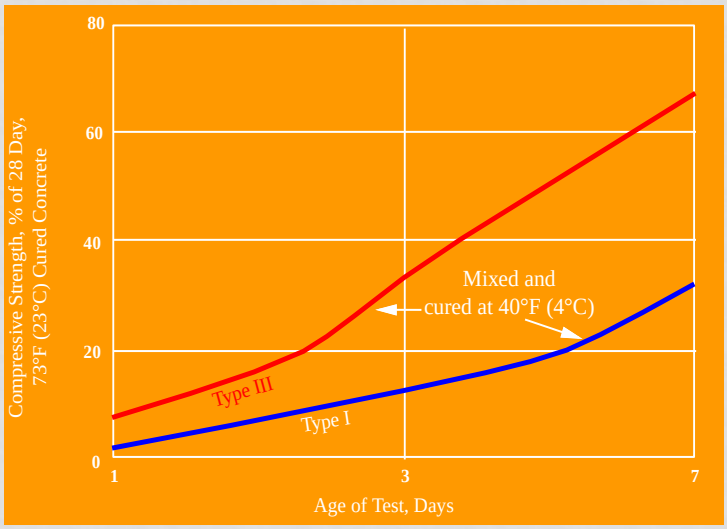


Chemical Admixtures for Concrete

ACI 212.3

"An accelerating admixture is a material added to concrete for the purpose of reducing the time of setting and accelerating early strength development."

"Accelerating admixtures are useful for modifying the properties of concrete, particularly in cold weather, to:"

Chemical Admixtures for Concrete

ACI 212.3

- Expedite the start of finishing operations
- Reduce the time required for proper curing and protection
- Increase the rate of early strength development to permit earlier removal of forms and earlier opening of construction for service

Accelerating Admixtures

Accelerated setting time characteristics

- Earlier finishing of slabs
- Increased early and ultimate strength
- Reduced protection time in cold weather
- Earlier stripping and reuse of forms

Classes of Accelerating Admixtures

Calcium Chloride

Accelerating admixtures containing calcium chloride

Non-chloride accelerating admixtures

Non-chloride accelerating admixtures for use in concrete placed in sub-freezing temperatures

Placing Concrete on Ground

- Concrete should never be placed on a frozen subgrade
- On a frozen subgrade, heat will migrate rapidly away from the bottom of the concrete retarding setting time
- Thaw the subgrade not just the surface
- Reschedule for a warmer day!!

Plastic Concrete Problems in Cold Weather

Concrete bleeding

- Bleed water can freeze on surface
- Bleed water capillary channels can freeze within the concrete

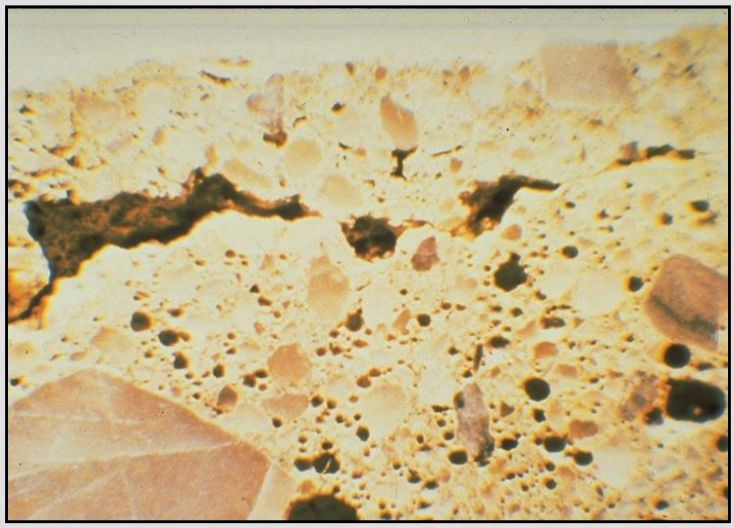
Cold subgrades

- Rapid migration of heat from concrete will affect setting time
- Uneven settlement may occur, causing cracking

Finishing Problems in Cold Weather

Surface crusting which can cause:

- Blisters
- Delamination
- Scaling (premature/over finishing)



Cold Weather Concreting Above Ground

All snow, ice and frost must be removed from forms, reinforcement and other embedments

Must protect from all sides

Use of Type III cement, additional cement and/or non-chloride accelerators will reduce the length of protection period, HOWEVER, know the effects each will have on the plastic and hardened properties


Picture #1


73.3

Table 3.1 – Recommended Concrete Temperatures

		Section size, minimum dimension, in.	
		<12 in.	12-36 in.
	Air Temperature		
Minimum Concrete temperature as placed and maintained			
1	-	55 °F	50 °F
Minimum concrete temperature as mixed for indicated air temperature			
2	Above 30 °F	60 °F	55 °F
3	0 to 30 °F	65 °F	60 °F
4	Below 0 °F	70 °F	65 °F

DURATION OF RECOMMENDED PROTECTION FOR % OF STANDARD-CURED 28-DAY STRENGTH

Percentage of Standard-cured 28-day strength	At 50 °F (10 °C), days Type of Cement		
	I	II	III
50	**6**	**9**	**3**
65	**11**	**14**	**5**
85	**21**	**28**	**16**
95	**29**	**35**	**26**

Concrete Curing

8.1 – Introduction — "Newly placed concrete must be protected from drying so that adequate hydration can occur. Normally, measures must be taken to prevent evaporation of moisture from concrete. During cold weather, when the air temperature is below 50 °F(10 °C), atmospheric conditions in most areas will not cause excessive drying."

Concrete Curing

8.2 - Curing during the protection period

When dry heating is used, the concrete should be covered with an impervious material or curing compound.

Water curing is not recommended.

Heating

Things to watch

- Carbonation CO_2
- Vent or have heat source from outside

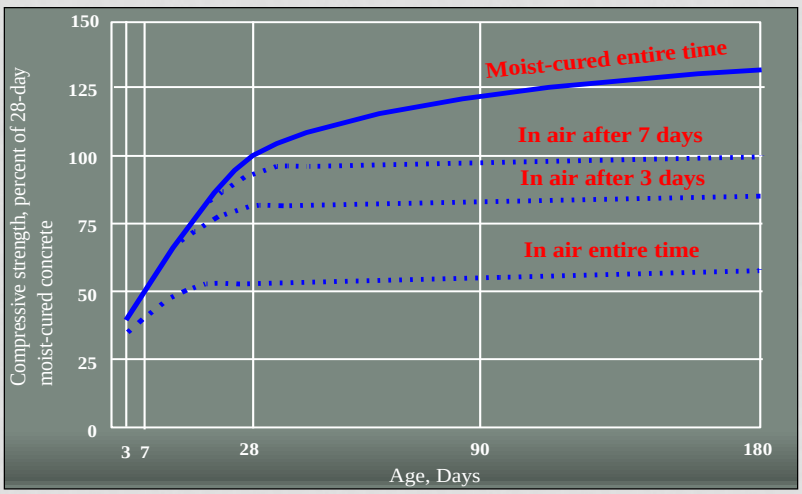
Watch Carbonation from other trades equipment

Watch blowing hot air across a fresh slab

Concrete Curing

8.3 - Curing following the protection period "…if a curing compound is applied during the first period of above-freezing temperature after protection is removed, the need to conduct further curing operations if the temperature should rise above 50 °F(10 °C) is eliminated."

Effect of Curing on Compressive Strength



Testing

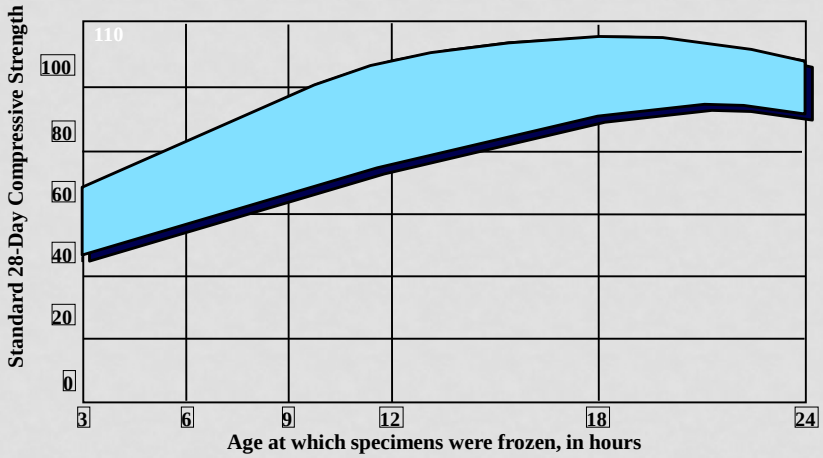
Cylinders should be protected and stored in protective area between 60°F and 80°F for the first 24 hours.

Record field storage conditions with a high / low thermometer.

Field cure cylinders for form removal should be representative of the structure and not used for quality assurance.

Recommend using maturity meter for in place strength data.

Effect of Freezing on 28-Day Compressive Strength



Sample Cold Weather Spec.

"Work on *your project named here* shall conform to all requirements of ACI 306.1,Standard Specification for Cold Weather Concreting, published by the American Concrete Institute, Detroit, Michigan, except as modified by the requirements of these Contract Documents."

Successful Cold Weather Concreting Practices

The entire team must:

- Plan ahead
- Be prepared
- Be concerned
- Schedule work
- Instruct and inspect

Conclusions and Recommendations

Quality concrete can be successfully placed at low ambient temperatures

ACI 306R Guide, ACI 306 specification and ACI 308 Guide should be followed

More cement, Type III Cement, heat and/or accelerating admixtures may all be used to accelerate concrete setting time and increase early strength development

Resources

"Cold Weather Concreting"
Reported by
ACI Committee 306

"Standard Specification for Cold Weather Concreting"
Reported by
ACI Committee 306

"Standard Practice for Curing Concrete"
Reported by
ACI Committee 308