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Low Temperature Concrete Admixture

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LOW TEMPERATURE CONCRETE ADMIXTURE

THE NEED

Performing construction processes under the cold weather condition requires construction engineers to plan operations considering low temperature condition. Especially, since the quality of concrete is sensitive to temperature, costly cold weather protection has been required to prevent damage due to inappropriate weather environment.

As temperatures drop, concrete sets more slowly, takes longer to finish, and gains desired strength less rapidly. If temperatures dip too low, the mix water may freeze and the final product will be irreparably damaged (Korhonen 2002).



FIGURE 1 CONCRETE POURING IN THE LOW TEMPERATURE
(COURTESY OF GRACE CONSTRUCTION PRODUCTS)

THE TECHNOLOGY

Concrete admixture mostly chemically interact with the constituents of concrete and affect the properties and characteristics of the fresh and hardened concrete and its durability. The purposes of the admixtures include water reduction, high strength, corrosion protection, crack control, finish enhancement, flowability, etc. One of the interesting and useful purposes is protection against freeze.





Accelerating admixture is to increase the rate of early strength development or to shorten the time of setting, or both. Some of these accelerating materials have properties effective to avoid freezing.

Calcium chloride which is now considered by many to be a main contributor to long-term concrete problems was the predominant accelerating admixture. Now, chloride-free set accelerators are available based upon other chemicals. Some of these newer admixtures also can act as ASTM C494 Type E water-reducers. These accelerators speed up the chemical reaction between cement and water forming gel, which bonds concrete aggregates together.

Pozzutec® 20+ developed by Master Builders, Inc. is a multi-component, nonchloride, water reducing and accelerating admixture formulated to accelerate concrete setting time and increase early and ultimate strengths across a wide range of ambient temperatures. Pozzutec® 20+ meets ASTM C 494 requirements for Type C and Type E. One of the most preferred feature is that it is effective for concrete placement at ambient temperatures as low as 20 °F (-7 °C), reducing or eliminating heating and protection time in cold weather.

PolarSet® from Grace Construction Products is a non-corrosive, non-chloride admixture for concrete, accelerating cement hydration resulting in shortened setting times and increased early compressive strengths. It is also formulated to comply with ASTM C 494 Type C. This admixture is specially formulated to be used for concrete in cold conditions as low as 20 °F (-7 °C).

In concrete mixes, these admixtures accelerate the chemical reaction between portland cement and water. Shorten setting time of concrete compensates for the set-slowing effects of cold weather. However, recent publications (Korhonen and Brook 1996, Korhonen and Orchino 2001, Korhonen et al. 2004) show that no commercially available admixtures, when used alone, will prevent fresh concrete from freezing at an internal temperature of -5°C although these admixtures will allow concrete to gain strength at air temperatures below zero. Korhonen et al. (2004) explain how combinations of commercial admixtures may be used to decrease the freezing point of concrete by at least 5 degrees, or more.

THE BENEFITS

- Effective for concrete placement at low temperatures as low as 20 °F (-7 °C).
- Increased early and ultimate strength
- Accelerated setting time
- Reduction of cost for heating and protection
- Earlier stripping



Performance Characteristics		
MIX DATA		
Type II cement, lb/cyd (kg/m ³)	600 (258)	
Slump, in. (mm)	4 ± 1 (100 ± 25)	
Air Content, %	Non-air-entrained concrete	
Concrete Temperature	55 °F (12 °C)	
MILD WEATHER		
SETTING TIME AMBIENT TEMPERATURE: 70 °F (21 °C)		
MIX	INITIAL SET h:min	TIME OF SET COMPARISON h:min
Plain	4:30	REF
Pozzutec 20+ admixture @		
10 fl oz/cwt (850 mL/100 kg)	3:18	-1:12
COLD WEATHER		
SETTING TIME AMBIENT TEMPERATURE: 50 °F (10 °C)		
MIX	INITIAL SET h:min	TIME OF SET COMPARISON h:min
Plain	5:48	REF
Pozzutec 20+ admixture @		
24 fl oz/cwt (1,920 mL/100 kg)	4:00	-1:48
SUBFREEZING WEATHER		
SETTING TIME AMBIENT TEMPERATURE: 30 °F (-1 °C)		
MIX	INITIAL SET h:min	TIME OF SET COMPARISON h:min
Plain	12:12	REF
Pozzutec 20+ admixture @		
60 fl oz/cwt (4,800 mL/100 kg)	3:54	-8:18
90 fl oz/cwt (7,200 mL/100 kg)	2:24	-9:48

FIGURE 2 PERFORMANCE DATA OF POZZUTEC® 20+
(COURTESY OF MASTER BUILDERS, INC.) (CLICK ON THE FIGURE FOR LARGE ONE)

STATUS

Korhonen et al. (1996; 1997) examined both products, and indicated that, with the proper dosages and formulation of various chemicals, the freezing point of concrete could be reduced and strength development at low temperature could occur at an acceptable rate without using external protection. Recently, the Cold Regions Research and Engineering Laboratory (CRREL) presented research results on chemical admixtures that allow concrete to be placed when its internal temperature is well below the freezing point water (Korhonen 1998, 2002).

BARRIERS

- Additional efforts for quality control
- Accurate mixing adjustment requested
- Limited compatibility with other admixtures

CERL is currently conducting a study funded by the Federal Railroad Administration (FRA) to assess track safety issues concerning the use of plastic crossties. This study is focusing on performance properties of the different manufacturers' plastic ties.



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REVIEWERS

Peer reviewed as an emerging construction technology

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