

Mortars: M, S and N.

Protection period: 0, 1, 2, 3 and 4 hours.

Prior to freezing: 1, 2, 3 and 4 days.

Temperatures: 0 F, 15 F, 30 F, and 70 F.

Cure period (after freezing): 3 hours and 28 days.

Admixtures: None, calcium chloride, ethyl alcohol and methyl alcohol.

Research work is continuing on the effect of freezing temperatures on clay masonry. However, the progress report, "Effect of Freezing Temperatures on Strength of Clay Masonry", September 1967, states: "In summary, the general trend of the data reviewed here suggests that neither the compressive strengths nor the bond strengths is significantly affected by the protection periods when exposed to the standard freezing conditions employed in the test program, namely a temperature level of 15 F held for a period of three days. However, when compared to controls, the compressive strength is about 70 to 80 per cent that of the 28-day strength. At 120 days, however, type I cement approaches control values but type III is roughly 85 per cent of control. Ultimate bond stress is not affected statistically by the freezing action. The temperature level and duration period were determined from a preliminary investigation which indicated these were the minimal conditions for obtaining discriminating test results. The preliminary testing indicated that, had the temperature level been held at a lower value, say 0 F, there may have been a greater delay in achieving high strengths; i.e., there is an expectation that at 28 days the strength results would have been less than those obtained in this program. However, from the winter exposure tests during which the specimens were cured over a period of 120 days, improved strength values are eventually expected, indicating that the freezing action tends to delay full hydration but does not necessarily destroy it. This is in agreement with the influence from not exceeding the critical degree of saturation, the benefits from the heat of fusion of the water, and the delay in lowering of the mortar temperature due to the heat capacity of the materials themselves, if they are laid at room temperature. Statistically, there is less influence on bond strength than there is on compressive strength from the freezing conditions of the test program. Concerning the use of admixtures, calcium chloride or alcohol, it appears that neither significantly reduces strength from a statistical viewpoint, although there is a trend toward the lowering of strength both compression and bondwise with increasing percentages of the admixtures."

In a paper, "Investigations on the Properties of Lime-Cement Mortars at Low Temperatures", by Tenho Snect, Lauri Kinnunen and Laila Koski of the State Institute for Technical Research, Otaniemi, Finland, the following appears in the introduction: "Frost damage is dependent upon the amount of water in the mortar during freezing. Concrete and bricklaying mortars differ, as water is removed from the fresh mortar by the suction of the bricks. It should thus be expected that freshly laid mortars and, consequently, masonry constructions would be less sensitive to frost than green concrete." This is confirmed by the test which they conducted. In the summary, they state: "In the opinion of the authors the results indicate that a mortar does not necessarily have to be detrimentally affected by freezing. The water content of the mortar at the moment of freezing is of importance and it can be effectively reduced by the use of bricks with a high suction."

COLD WEATHER MASONRY CONSTRUCTION—CONSTRUCTION AND PROTECTION RECOMMENDATIONS

GENERAL PROTECTION REQUIREMENTS

Current code requirements, research and observations on cold weather construction are covered in *Technical Notes*, No. 1 Revised, December 1967, "Cold Weather Masonry Construction, Introduction." The following recommendations are made, based upon cited and uncited research, observations of masonry performance when built under freezing conditions and the procedures used in other countries for cold weather masonry construction. It is believed that these recommendations are conservative and probably will be revised as a greater understanding of cold weather masonry construction is gained.

Construction projects vary greatly in size, height, design, location in relation to adjoining structures, and many other respects. Consequently, the most economical methods of protecting and heating a particular project can be deter-