



Fig. 8.12—(a) Applying a steel trowel finish to freshly gunned shotcrete finish; and (b) final finish appearance.

### 8.7—Tolerances

Tolerances should be based on use and function. Typically, shotcrete structures are not required to meet the tolerance standards of cast-in-place concrete. Tolerance requirements for many shotcrete applications, such as underground support, below-grade walls, and slope stabilization, may vary as much as 4 in. (100 mm). If needed, shotcrete can be finished to tight tolerances. Some of the economy that shotcrete placement brings to a project, however, may be lost if tight tolerances are specified.

### 8.8—Curing

Shotcrete, like concrete, should be properly cured so that its potential strength and durability are fully developed. This is particularly true for the thin sections and low  $w/cm$  associated with shotcrete. The best method for curing is to keep the shotcrete wet continuously for 7 days while maintaining a temperature over 40 °F (5 °C). The temperature of the curing water should not be lower than 20 °F (10 °C) cooler than the

shotcrete surface at the time the water and shotcrete come in contact. Covering shotcrete with sheet materials (ASTM C 171) is another method used to cure shotcrete.

Curing compounds are satisfactory if drying conditions are not severe, no additional shotcrete or paint is to be applied, and the resulting appearance is acceptable. Where the surface has a natural gun or flash finish, the liquid membrane-curing compound (ASTM C 1315) should be applied at a rate twice that recommended by the compound manufacturer. A fugitive dye is helpful to monitor coverage. Natural curing may be allowed if the relative humidity is continuously maintained at or above 85%. More detailed information on curing can be found in ACI 308.1 and ACI 506.2. The crew should avoid rapid drying of shotcrete at the end of the curing period.

### 8.9—Hot-weather shotcreting

With dry-mix shotcrete, the time from mixing to shooting a mixture should not exceed 15 minutes; otherwise, undesirable decreases in strength due to prehydration can occur.

With wet-mix shotcrete, the undesirable effects are similar to those encountered with normal pumped concrete. The problems include increased water demand, increased rate of slump loss, increased rate of set, and difficulty in regulating entrained air content. There should be procedures to handle these problems to ensure a satisfactory shotcrete installation.

Once the shotcrete is in place, placing, finishing and curing procedures are similar to those for concrete. Screeding and finishing operations should proceed as rapidly as the shotcrete conditions allow. Curing should start promptly after finishing is completed. Ideally, the temperature of the shotcrete should be maintained between 50 and 100 °F (10 and 38 °C) during all phases of the installation procedure. ACI 305R should be referred to for more detailed information.

### 8.10—Cold-weather shotcreting

The shotcreter should not place shotcrete on frozen surfaces. This and other precautions used to protect concrete from freezing should also be used for protecting shotcrete. Shotcrete has a greater heat of hydration than conventional cast-in-place concrete because of its higher cement factor that aids in resisting freezing, but it is placed in thin layers with large surface areas providing for rapid loss of heat that partially counter-balances the heat of hydration benefits. Shooting can be allowed if the temperature is at least 40 °F (5 °C) and rising and discontinued at 40 °F (5 °C) and falling. At low temperatures, however, strengths will develop slowly until higher temperatures are restored. Low temperatures will reduce the rate of hydration and may inhibit setting and early-strength development.

Once the shotcrete is in place and finished, it should be cured and protected from freezing until it reaches sufficient strength. Water curing in a freezing environment is not recommended. The temperature during curing should be maintained above 40 °F (5 °C). When shotcrete will be placed under cold-weather conditions, a plan should be developed outlining procedures for surface preparation, shotcrete placement, curing, and protection. Shotcrete can be