voids. When conventional forms are used, however, they usually provide automatic alignment control, eliminating the need for special devices for line and grade control. The nozzle operator should control the nozzle technique to prevent the formation of sand pockets and other defects.

5.7—Joints

5.7.1 *Contraction/expansion joints*—Joints may be provided by the prepositioning of full-thickness strips, usually wood or steel, that are left in place, or by tooling a groove in the plastic shotcrete, or by saw-cutting the shotcrete shortly after it has achieved final set. Joint spacing depends on the application and its design, and should be designated on the plans. In practice, the spacing usually varies from 15 to 30 ft (5 to 9 m). When shooting over an existing joint, the new joints should coincide with the existing joints.

5.7.2 *Construction joints*—Square construction joints are generally avoided in shotcrete construction because they form a trap for rebound and overspray. Construction joints are usually constructed at a 45-degree angle. Where the joint will be subjected to compressive stress, however, square joints are sometimes required, in which case the crew should take the necessary steps to avoid or remove trapped rebound at the joint. Before applying additional shotcrete, the entire joint should be thoroughly cleaned and wetted, and allowed to dry to a saturated surface-dry condition.

When a section of shotcrete is left incomplete at the end of a shift, provisions should be made to ensure the joint will not develop a plane of weakness at this location. Therefore, the joint is tapered to an edge, usually about 1/2 the thickness of the shotcrete, a maximum of 1 in. (25 mm). A better appearing joint may be constructed by sloping to a shallow edge using a 1 in. (25 mm) thick board placed flat.

5.8—Protection of adjacent surfaces

Rebound, overspray, and dust resulting from the shotcrete application can contaminate adjacent structures, equipment, and grounds. This problem is especially aggravated on windy days. Therefore, it is important to evaluate the effect of the shotcrete application on adjacent surfaces and make the necessary arrangements to protect them. Ideally, isolate the shotcrete operation from areas or surfaces needing protection. Although this is not always possible, protection can take the form of a cover, masking materials, or temporary protective coatings. Covers may include plywood or similar materials, polyethylene film, or drop cloths. Masking materials are usually used in conjunction with the above materials. Temporary protective coatings include grease, diesel oil, and other materials that can be removed without too much difficulty.

If none of the above are practical, adjacent surfaces should be cleaned and washed before the rebound and overspray hardens. The protection of adjacent surfaces should include concern for the buildup of overspray, rebound, and dust on surfaces that receive shotcrete. If these materials are allowed to build up, they will cause low shotcrete strength and interfere with bonding.

CHAPTER 6—PROPORTIONING AND PRECONSTRUCTION TESTING

6.1—Introduction

Shotcrete mixtures are usually proportioned to attain a specified compressive strength. The main reasons for variations of in-place strength are the nature of the shotcrete process, type of delivery equipment, and quality of workmanship. This is especially true of dry-mix shotcrete, where the nozzle operator is not only responsible for the proper placement technique but also regulates and controls the water content—a variable that can cause fluctuations in strength.

In certain applications, particularly those with thin layers of shotcrete, properties other than compressive strength may be more important for a successful application. Qualities such as permeability and durability may have to be considered, requiring some alteration in the mixture proportions.

There is a wide range of shotcrete equipment, as described in Chapter 3, and no single mixture proportioning criteria can be applied in all cases. Before proportioning a mixture, the following should be considered:

- Preferred characteristics of the shotcrete work and the constraints involved;
- The type of specification selected for the work, performance, or prescription; and
- The type of shotcrete placing equipment appropriate for the work: wet-mix or dry-mix, each with or without coarse aggregate.

6.2—Performance versus prescription specification

There are two general approaches to specifications: the performance method and the prescription method. A performance specification should be used whenever possible. When possible, the installer should be consulted on the types of cement, aggregate, and shotcrete equipment available and the shotcrete properties that can be achieved with local materials.

6.2.1 *Performance specification*—The performance specification states the required quality of shotcrete. Applicators decide how to achieved the specified performance. Typically, these parameters might be specified:

- Cement type;
- Aggregate gradation;
- Compressive strength at specified age;
- Slump, if wet-mix;
- Air content, if wet-mix;
- Specific performance requiring use of admixtures; and
- Specific performance of fiber shotcrete.

In many applications, specifying compressive strength alone is adequate.

Mixture proportions should be developed as part of the preconstruction test program or be based on previous experience.

6.2.2 *Prescription specification*—The prescription specification should only be used for special job requirements or to limit the work to a particular type of shotcrete. Typically, the following would be specified:

- Cement type and content;
- Aggregate gradation, mass, or volume;