CHAPTER 8
APPLICATION TO TUNNELS, SHAFTS, AND CHAMBERS

8-1. General Applications: The areas of application covered in this chapter have found ever-increasing uses in civil projects. Subsurface structures requiring isolation from water and hardening for resistance to shock frequently are treated by grouting.

8-2. Purposes of Grouting. The purposes of grouting tunnels, shafts, and chambers are generally to consolidate the surrounding materials and to protect the structures from the following:

a. Water infiltration.

b. Chemical attack.

c. Shocks.

d. Instability.

e. Radiation (waste disposal).

f. Uneven load transmittal or distribution.

8-3. Applications.

a. Tunnel Treatment. Water infiltration or unstable conditions during driving operations or into old sections of tunnels may require pressure grouting. The grouting is usually accomplished using portland cement or chemical grouts, or combinations of both.

(1) Grout holes. Holes are oriented to best intercept known or suspected fissures, weak zones, and fractures in rock. Size of drilled holes may range from AW (48 millimeters) to NW (75.7 millimeters). A primary system of holes is initially drilled on selected spacing. Pneumatic or mechanical packers are placed near the collar of the hole. Water, sometimes dyed, is used to pressure test the area being prepared for grouting. Pressure gages are placed in-line at the hole collar and at the pump discharge head. Grout is injected and carefully monitored for take and pressures. Split-spacing may be required to accomplish additional grout injection. Grout mixtures, pressures, pumping rates, depth of grout holes, and drilling and grouting sequence of the holes are determined in the field. In flowing water conditions the use of quick-setting grouts incorporating accelerators with the possible addition of fillers, such as chopped and shredded cellophane, shredded rubber, sawdust, crushed cottonseed hulls, and high-density fines, have in some instances completely sealed or reduced the flow to acceptable levels. Chemical grouts have also been very effective due to their controlled gel time. Applications for

seepage cutoff in dam projects are described in paragraph 5-5, and additional discussion is given in EM 1110-2-2901.

(2) Equipment. Standard drilling and grouting equipment should be of the electric- or air-powered type normally used for underground work. The equipment should be sufficiently durable, compact, and light for easy transport. Telephonic communications are frequently necessary between the header and grout pump.

b. Shaft Treatment. Ring grouting is normally employed to seal a permeable, water-bearing formation or rock fissures and fractures prior to shaft sinking. The treatment is accomplished by drilling a series of angled or vertical holes from the perimeter of the planned shaft. Combinations of portland cement and chemical grouts may be employed for such applications. Before the grout is injected, pumping tests are conducted using water to indicate grout takes as well as to ascertain a range of gel times for the chemical grouts, assuming that these grouts may be pumped as easily or nearly as easily as water. After the primary ring of holes is grouted, a second and possibly a third ring may be required. Split spacing of holes may subsequently be necessary in one or more of the rings to form an adequate ring curtain. As the shaft sinking advances, additional grouting may be required from inside the shaft if the degree of permeability encountered downshaft is judged to be undesirable.

c. Liner Grouting. Liner grouting is normally undertaken following the placement of tunnel or shaft liners, which are usually constructed of concrete but may also be constructed of steel. Grouting of the space between liners and the formations in which liners are placed is referred to as backpack grouting. This grouting usually requires the use of portland cement grouts. The grout is injected from the invert of the liner for a tunnel and displaced upward. Holes drilled above the injection points provide venting as well as determine the progress of grouting and may later be used as injection points. Backpack grouting at the tunnel crown contact area requires that pressure be maintained until hardening of the grout occurs to ensure intimate contact of the grout with the crown. Expansive cement grouts are frequently used to contact grout crowns after the backpack grout has hardened. For shaft linings, a series of radial holes is drilled and grouted from the inside of the shaft. Hole spacing and sequence will vary, but usually split-spaced secondary holes will be drilled and grouted. Closely monitored low to moderate pumping pressures are used to inject grout behind liners.

d. Consolidation Grouting. Where excavation of a tunnel or chamber has loosened the surrounding rock, or caused minor movements prior to lining placement, it may be necessary to consolidate the rock and fill open joints and fractures. In these cases grout holes can be drilled through the lining to the depth of disturbance, and grouting accomplished as described in paragraph a above.

e. Permanent Drain Holes. Permanent drain holes are drilled to intercept seepage through structures to relieve uplift and hydrostatic pressures. These holes should always be drilled after the completion of all grout injections conducted in a particular area. Drain holes 3 inches in diameter will be adequate for most conditions. The spacing of drain holes can range from a few feet to as much as 20 feet. The spacing is largely based on the permeability of the areas to be drained, and close spacing is required for areas of low permeability.