Chapter 2
Investigation and Selection of Materials

2-1. Policy

Policies for RCC dams regarding the investigation of concrete materials and the scope of the required investigation are the same as for a conventional concrete dam and are discussed in detail in EM 1110-2-2000. It is necessary to assess the availability and suitability of the materials needed to manufacture RCC with qualities meeting the structural and durability requirements. An availability investigation should particularly emphasize the need to meet any high RCC production and placement rates. Additional investigations may be needed for RCC in various applications, as appropriate.

2-2. Cementitious Materials

a. General. The method of investigating cementitious materials for RCC is similar to that used for conventionally placed concrete and should be in accordance with EM 1110-2-2000. The selection of cementitious materials significantly affects the rate of hydration and strength development. The use of pozzolan is quite common for RCC projects and generally provides for reduced cost and lowered heat generation. Pozzolan contents ranging up to 80 percent by volume of the cementitious material have been used by many design organizations.

b. Cement. Type II portland cement is more commonly used with RCC because of its low heat generation characteristics at early ages and its longer set times. The use of Type III portland cement is not practical for most RCC applications because it shortens the time available for compaction and increases heat evolution at early ages. The slower rate of strength development of some cements generally results in greater ultimate strength for a given cement content.

c. Pozzolan. The use of a pozzolan or ground slag may be especially beneficial in RCC as a mineral filler and for its cementitious properties, as well as providing a degree of lubrication during compaction. Pozzolan occupies some of the paste volume otherwise occupied by cement and water. Class F fly ash is most commonly used as a pozzolan or mineral filler for RCC but Class C fly ash has also been used. Class F fly ash contributes to lower heat generation at early ages, may be used to replace cement (generally up to approximately 50 percent by volume), reduces cost, acts as a mineral filler to improve workability, and delays final set. Therefore, RCC mixtures containing Class F fly ash benefit from increased placement time and increased workability. Laboratory testing should be conducted to verify and evaluate the benefits of using pozzolan.

2-3. Aggregates

a. General. One of the most important factors in determining the quality and economy of concrete is the selection of a suitable source of aggregate. This statement is as true for RCC as for conventional concrete. The investigation of aggregates will follow the procedures described in EM 1110-2-2000.

b. Aggregates for RCC. As with conventional concrete, aggregates for RCC should be evaluated for quality and grading. Aggregate for RCC should meet the standards for quality and grading as required by the desired properties for the design structure. The use of lesser quality aggregate may be appropriate for certain circumstances, such as construction during an emergency situation, when the use of a poorer quality aggregate does not affect the design requirements of the RCC, or where specific material properties can be achieved with the use of such aggregates. Changes from the grading or quality requirements must be supported by laboratory or field test results included in a design memorandum. The design memorandum should identify that the concrete produced from the proposed materials fulfills the requirements of the project for strength, durability, water tightness, and economy. The typical nominal maximum size of aggregate (NMSA) particle which has been handled and compacted in Corps of Engineers RCC construction is 75 mm (3 in.). However, the gradings may be significantly different than those normally used for conventional mass concrete. While larger sizes have been successfully used in Japan and at Tarbela Dam, the use of NMSA larger than 75 mm (3 in.) will seldom be technically justified or economically viable in most Corps of Engineers structures. Use of larger aggregate greatly increases the probability of segregation during transporting and spreading RCC and seldom significantly reduces the RCC cost. A proposal to use aggregate larger than 75-mm (3-in.) nominal maximum size should be included in a design memorandum and

should be accompanied by results from an investigation showing that the larger aggregate can be handled without segregation, can be compacted, and that its use will actually result in lower costs.

c. Fines in aggregate. When low cementitious material content RCC is used, the required amount of material passing the 75-μm (No. 200) sieve is greater for RCC than is acceptable for conventional concrete. The larger percentage of fines is used to increase the paste content in the mixture to fill voids and contribute to workability. The additional fines are usually made up of naturally occurring nonplastic silt and fine sand or manufactured fines. Although the greatest benefit from the use of fines is the control of segregation, in many cases the use of fines increases water demand, thus lowering strength. Care should be exercised when selecting aggregates with plastic versus nonplastic fines. When plastic fines exist in aggregate, an evaluation of the effects of strength loss, water demand, and durability should determine the feasibility of meeting the structural design requirements. When pozzolans are used to replace natural fines, workability improves while w/(cm) ratios decrease and long-term strength may increase.

2-4. Water

Criteria for assessing available water supplies as sources of mixing and curing water are given in EM 1110-2-2000. Experience has shown that the source of water (groundwater vs. surface water) can have a significant effect on RCC performance. Times of setting and strength development can vary significantly. Caution should be exercised when accepting a water supply, and acceptance should be contingent on appropriate verification of performance.

2-5. Chemical Admixtures

a. General. Chemical admixtures have been effective for modifying RCC mixtures proportioned for workability levels in the 10-20 sec Vebe range. Admixtures can be used to improve workability, delay time of setting, and improve durability of such mixtures. Larger quantities of admixtures are typically required for RCC than for conventional concrete, thus increasing the relative cost.

b. Water-reducing and retarding admixtures. The use of a water-reducing and retarding admixture or a retarding admixture, Type B or D, according to CRD-C 87[1] (American Society for Testing and Materials (ASTM) C 494), should be considered for any RCC placement. The use of a water-reducing and retarding admixture has proven to be beneficial for extending workability of RCC and increasing the initial and final times of setting, thereby enabling a better bond and increasing the likelihood of a watertight joint. The extended workability is especially beneficial during warmer weather, during RCC startup activities, for transporting RCC from distant sources, and for placement of 600-mm- (24-in.-) thick lifts. The addition of the water-reducing and retarding admixture will normally increase the workability of the RCC mixture and result in a decreased water content. Dosages of water-reducing and retarding admixtures can be several times as much as recommended for conventionally placed concrete because of the drier consistency of RCC; however, in some instances, excess dosages of water-reducing and retarding admixtures for lean RCC mixtures can result in minimal improvement in or, at times, detrimental impact on short-term and long-term performance. Dosage should be based on results of laboratory tests where the effect of varying dosages are evaluated.

c. Air-entraining admixtures. Air-entraining admixtures have been added to RCC mixtures in attempts to entrain an air-void system with proper bubble size and spacing to resist damage to the concrete when it is subjected to repeated cycles of freezing and thawing while critically saturated. Experience indicates that the dosages of air-entraining admixtures required for RCC may be considerably higher than those required for conventionally placed concrete; however, the air content required to achieve significant freeze-thaw protection may be lower and the air bubble shape may not be as critical as for conventional concrete. As with conventional concrete, the workability of the RCC may be visibly improved by the addition of air-entraining admixtures, resulting in a reduction of the amount of mixing water required. The fines content, type of fines, and water content of RCC mixtures significantly influence the effectiveness of air-entraining admixtures. An examination of air-entrained RCC cores obtained from the RCC dam at Fort Ritchie, MD, revealed an air-void structure different from that normally observed in conventional concrete. The air voids in the RCC exhibited very irregular shapes compared with

[1] All CRD-C designations are to *Handbook for Concrete and Cement*, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

conventional concrete, but the bubble spacing factors were comparable. Testing of various RCC mixtures at the U.S. Army Engineer Waterways Experiment Station (WES), though limited in scope, indicates that certain brands of air-entraining admixtures perform significantly better than others, although frost resistance was moderate at best. Laboratory and field evaluations should be performed to determine the effectiveness of various brands of admixtures and the quantities required to meet design criteria. In most instances, the development of air-entrained RCC in the laboratory has proven less difficult than producing and controlling air-entrained RCC under field conditions. A relatively new approach to entrainment of air into exposed RCC facings is to pour air-entrained, cementitious grout over about a 0.4-m (1.3-ft) strip of the RCC lift surface along the vertical formwork. Once the grout soaks into the RCC, the mixture can be successfully consolidated with internal vibrators to form a homogenous, impervious facing of air-entrained RCC (Forbes 1999). The grout-enriched RCC technique has been successfully used in nearly all of the RCC dams constructed in China during the 1990's. The method has also been used with similar success at the recently completed Cadiagullong Dam in Australia and Horseshoe Bend Dam in New Zealand and is currently in use at the Beni Haroun Dam in Algeria.