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Guide for the Use of Preplaced Aggregate Concrete for Structural and Mass Concrete Applications

Reported by ACI Committee 304

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ACI Committee 304 expresses its appreciation to John C. King for his work as the principal author of this document. Beginning in 1947, he evaluated data, prepared specifications, and guided the conversion of repair procedures into those more suitable for new construction with preplaced aggregate concrete.

This guide explains the preplaced aggregate (PA) method for concrete construction, describes special properties, and gives materials requirements where they differ from those used in normal concrete. A brief history of the development of the procedure is covered. Short descriptions of several typical applications are included.

Keywords: fluidizing; grout; heavyweight concrete; inserts; preplaced aggregate concrete; underwater construction.

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CHAPTER 1—INTRODUCTION

This report on preplaced aggregate (PA) concrete for structural and mass concrete applications describes practices as developed over many years by engineers and contractors in the successful use of the method; defines the reasons for material requirements that are different from those usually specified for normal concrete; and provides information on equipment, forms, aggregate handling, and grouting procedures. A brief history of the development of the method is given. Photographs with short descriptions for a few major applications are used to illustrate techniques.

PA concrete, the finished product, is defined in ACI 116R as "Concrete produced by placing coarse aggregate in a form and later injecting a portland cement-sand grout, usually with admixtures, to fill the voids." Other terms describing the method, used both in America and internationally, include grouted aggregate concrete, injected aggregate concrete, two-stage concrete, Prepakt, Col-Crete, Naturbeton, and Arbeton. PA concrete is particularly useful for underwater construction, placement in areas with closely spaced reinforcement and in cavities where overhead contact is necessary, repairs to concrete and masonry where the replacement is to participate in stress distribution, heavyweight (high-density) concrete, high-lift monolithic sections and, in general, where concrete of low volume change is required.

1.1—History

Lee Turzillo and Louis S. Wertz conceived the PA method of producing concrete circa 1937 during rehabilitation work in a Santa Fe railroad tunnel near Martinez, Calif. When grouting voids in the concrete at crown areas, the grouting crew began filling larger spaces with coarse aggregate before

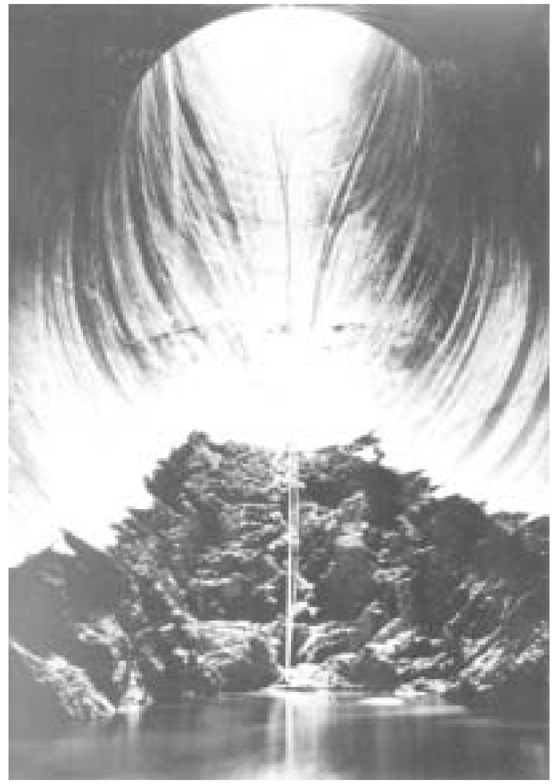

Fig. 1.1—Eroded area in spillway tunnel at Hoover Dam, 500 ft (152 m) below crest, before repair with PA concrete.

grouting to reduce the consumption of grout. The next logical step was to form over the areas where concrete was to be replaced, place a graded aggregate into the forms, and grout the aggregate. The resulting "concrete" showed such promise that Professor Raymond E. Davis was engaged to develop grout mixtures and basic procedures to make the method viable. In the course of this work, Davis also determined most of the unique properties of PA concrete, which are cited elsewhere in this guide. A series of patents on the method (trade-named Prepakt) and admixtures, mainly grout fluidifier, were applied for and granted in about 1940. All patents have expired, with the possible exception of some on admixture refinements.

Initially, in view of the lack of any performance history, the use of PA concrete was limited to the repair of bridges and tunnel linings to extend their usefulness. After extensive laboratory testing, the Bureau of Reclamation backfilled a large eroded area in the spillway at Hoover Dam.[1,2] The replacement was 112 ft (34 m) long by 33 ft (10 m) wide and up to 36 ft (11 m) deep, as shown in Fig. 1.1. The next major project was the addition to the upstream face to Barker Dam[3] at Nederland, Colo., in 1946. This resurfacing of the 170 ft (52 m) high dam involved anchoring precast concrete slabs some 6 ft (1.8 m) in front of the dam, as shown in Fig. 1.2, and backfilling the space with coarse aggregate during the winter when the reservoir was empty. The aggregate was grouted in late spring in a 10-day continuous pumping operation with the reservoir full. This work proved the method usable for construction. In 1951, the U. S. Army Corps of Engineers began to permit its use for the embedment of turbine scroll cases, as illustrated in Fig. 1.3, and other structures. During 1954 and 1955, approximately 500,000 yd^3 (380,000 m^3) of PA concrete were used in construction of the 34 piers of the Mackinac Bridge.[4] In 1950, construction companies in Japan bought rights to the method and built several bridge piers. During the 1970s, the Honshu-Shikoku Bridge Authority engaged in extensive research culminating in the construction of a large bridge complex. The Snowy Mountains Authority, Australia, used PA concrete for embedding turbine scroll cases and draft tubes in its hydroelectric power projects. The method also found wide use in placing biological shields around nuclear reactors and x-ray equipment. B. A. Lamberton and H. L. Davis were largely responsible for the development of heavyweight (high-density) PA concrete.

1.2—General considerations

The design of structures using PA concrete should follow the same requirements as conventionally placed concrete. The designer may take advantage of certain favorable physical properties and placement procedures summarized in the following sections.

1.3—Special properties

PA concrete differs from conventional concrete in that it contains a higher percentage of coarse aggregate because coarse aggregate is deposited directly into the forms with point-to-point contact rather than being contained in a flowable plastic mixture. Therefore, the properties of PA concrete are more dependent on the coarse aggregate. The modulus of elasticity has been found to be slightly higher and the drying shrinkage less than half that of conventional concrete.[5-7]

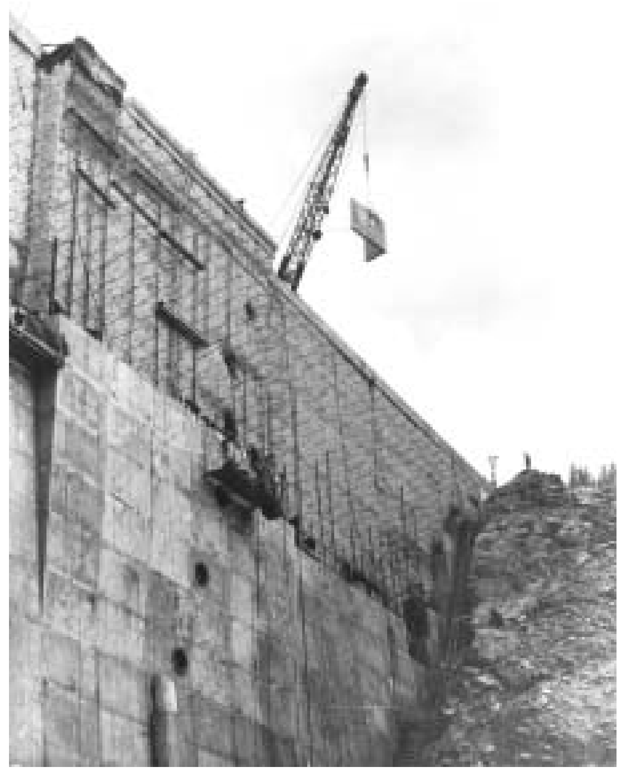

Fig. 1.2—Barker Dam, Colorado, during refacing in 1946. Coarse aggregate placed behind precast concrete slab forms for the entire upstream face of the dam (170 ft [52 m] high by 1300 ft [400 m] long at crest). Grout was placed in one continuous, 10-day pumping operation after the reservoir had been refilled to load the dam and cool the aggregate. Behind the form concrete, the new face has no joints of any kind.

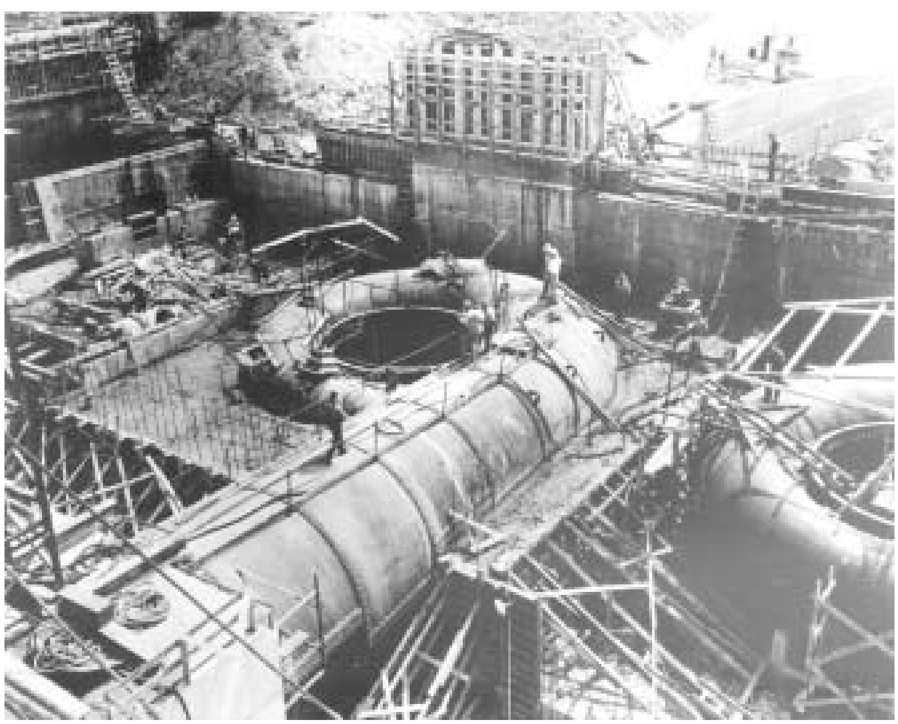

Fig. 1.3—Turbine scroll case at Bull Shoals Dam powerhouse at completion of the first (10 ft [3 m]) lift of PA concrete. A second lift completed the embedment.