Practical Guide to
GROUTING
of Underground Structures

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CONTENTS

PREFACE

Grouting is a part of most underground civil engineering and mining projects. Depending on the type and operating parameters of the underground facility, geology, and groundwater conditions, grouting can represent a sizable cost and scheduling component of a project. This book is written as a practical guide for engineers, construction supervisors, inspectors, and others involved in the planning, design, and implementation of underground grouting programs. Its primary purpose is to present a hands-on discussion of grouting fundamentals and to provide a foundation for the development of practical specifications and field procedures for underground grouting applications. The reader is encouraged to combine the information in this book with other information sources on grouting. An excellent companion book to this one is *Dam Foundation Grouting*, by Ken Weaver, published in 1991 by the American Society of Civil Engineers.

Cementitous grouting used in conjunction with the excavation and lining of tunnels, shafts, and underground caverns in rock is the primary focus of this work. Overviews of cementitous grouting in soils and chemical grouting are also provided.

The guide takes a practical approach to the subject of underground grouting by concentrating on areas such as grouting methods; types of drilling, mixing, and pumping equipment; and their application. Grouting materials and specifications, record keeping, quality control and testing requirements, field operations, and production rates are also covered. These are all important elements to the overall success of a grouting program, yet they are usually not addressed in detail in engineering literature on grouting.

The guide is intended to compliment existing engineering literature by presenting grouting equipment, technology, and methodologies that are presently available. This information will enhance the planning, field implementation, and quality of an underground grouting program. A better understanding of the capabilities and limitations of the art and science of grouting can only improve the overall results and performance of a grouting program. The text is written assuming that the reader has a basic knowledge of geology, engineering principles, and underground construction methods.

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CHAPTER 1

INTRODUCTION

The development of cementitious permeation grouting got its start as a method to improve the foundation material of civil engineering structures built in and around bodies of water. The concept of injecting self-hardening cementitious slurry was first employed in 1802 in France to improve the bearing capacity under a sluice (Bruce 1995). The development of cement grouting continued in France and England throughout the 1800s. The applications were concentrated on civil structures such as canals, locks, docks, and bridges (Bruce 1995).

The first recorded use of cementitious grout in underground construction was when, in 1864, Peter Barlow patented a cylindrical one-piece tunnel shield with a cast iron liner constructed from within. The annular void left by the tail of the shield was filled with grout (Tirolo 1994). In 1893 the first systematic grouting of rock in the United States was performed at the New Croton Dam, in New York (Weaver 1991). The grouting program at the Hoover Dam between 1932 and 1935 is said to mark the beginning of systematic design of grouting programs in the United States (Glossop 1961).

The development and advances of underground grouting technology in soil and rock as they apply to design, equipment, and materials have for the most part paralleled the advances made in dam and foundation grouting preformed from the surface. Today, most underground civil engineering and mining projects require some form of grouting. Depending on the type and operating parameters of the underground facility, the geology, and groundwater conditions, a grouting program can represent a considerable cost and scheduling component of a project.

Grouting performed in conjunction with engineered underground structures, such as tunnels, shafts, chambers, and mine workings, is similar to grouting operations performed from the surface, such as installing a grout curtain for a dam. In both cases grouting is used to fill pores, fissures, or voids in the host geologic materials to reduce seepage, to strengthen foundation material, or to improve ground-structure interaction.