Book Review by

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Handbook on Mine Fill

Published by the Australian Centre for Geomechanics
Edited by Yves Potvin, Ed Thomas, Andy Fourie

The Australian Centre for Geomechanics (ACG) recently published a *Handbook on Mine Fill*. Billed as the essential reference on current fill practices in the mining industry, the book is a collaborative effort from a number of well known practitioners, primarily from Australia.

The need for such a volume is clear. The existing technical library on mine fill practices and research is spread amongst a large number of symposia and conference proceedings such as the Minefill series of symposia held every four years. The latest Minefill symposia (Minefill 2004) was held last fall in Beijing, China. While the technical knowledge contained in these many proceedings is exhaustive, there are very few textbooks written on the topic.

The last attempt to combine the available references into one volume was the "Mine Backfill 1998" electronic textbook (CD) sponsored by the Metal Mining Division and the Rock Mechanics Committee of the Canadian Institute of Mining Metallurgy and Petroleum (CIMM). This volume covered a variety of topics in eight chapters, ranging from backfill mechanics and backfill designs, through to detailed chapters on hydraulic fills, rockfills, paste fills and salt fills. The CD also contained an extensive literature review as well as several case studies of Canadian operations. Being authored by university researchers in Canada, however, much of this reference was theoretical in nature and was lacking in practical advice.

The Handbook editors note the last Australian reference on mine fills was written in 1979 by noted Australian backfill practitioner Ed Thomas. However, the field of mine filling has evolved significantly in the 25 years since this volume was published and today we have a much better understanding of the properties and behavior of backfill materials, as well as access to technologies and equipment that did not exist in that day.

The ACG *Handbook on Mine Fill* comprises 10 chapters spanning a diverse range of engineering sciences employed in the application and use of backfills in mining. The key subjects include soil mechanics and fluid mechanics, mineral processing, environmental engineering and the chemistry of cements and pozzolans.

The introductory chapters 1 and 2 cover the need for mine backfill in the mining cycle, considerations for the selection of a mine fill system, a history of mine fill, along with a review of the properties of the basic materials that comprise mine fills, namely: tailings, sand, rock, water, cement and other binders.

Chapters 3 and 4 cover geomechanics and fluid mechanics of mine fills. These topics span some of the most technically challenging, and poorly understood, aspects of mine fills. Chapter 3 first walks the reader through the basic soil mechanics parameters as they relate to mine fill materials, such as volumetric relationships, shear strengths, permeability and arching in fills. Chapter 4 then covers the equally important fluid mechanics aspects of mine fills including the behavior of hydraulic fill slurries and paste fills, reticulation designs for hydraulic fills and paste fills, and drainage of backfills.

The importance of these topics, and the unfortunate lack of understanding by many mine operators, is illustrated by the chronicles of recent failures at backfilling operations in Australia and worldwide due to hydraulic fill piping events, bulkhead collapses, and fill failures.

Chapter 5 is dedicated to hydraulic fills, starting with the selection of materials. The chapter gives an excellent overview of the preparation of hydraulic fills including desliming and dewatering of tailings, design principles, barricade designs, and finally monitoring and performance. In appreciating the importance of this chapter it should be remembered that, worldwide, the vast majority of mine fills comprise hydraulic fills. In major mining regions such as Peru, hydraulic fills are the norm.

Chapter 6 covers paste fills. This chapter follows the progression from the selection of materials, processing of components (including thickening and dewatering), mixing, delivery and placement in stopes, and monitoring/performance. The chapter includes an extensive discussion on the key design principles for paste including rheology and backfill strengths. Given the ever increasing demand for paste this chapter will likely be popular with readers. In particular, the authors reinforce some of the fundamentals key to the success of paste systems such as adequate

fines, matching the rheology of the paste to the hydraulics of the system, and maximizing the use of gravity for delivery. These factors are critical in that most performance failures in paste systems can be attributed to rheology.

Chapter 7 presents a comprehensive overview of rockfills. The chapter first covers some of the mechanics of rockfills based on the aggregate gradings, backfill density, and aggregate types. It then covers some of major design elements including aggregate gradings, binder additions, and delivery to stopes. The remainder of the chapter is dedicated to a discussion of several varieties of composite rockfill/hydraulic fill (so called rocky paste fills) in use at Mount Isa and Olympic Dam. These fills offer a number of advantages to large blasthole open stoping operations including remarkable backfill strengths at very low bulk cement contents.

Rockfills are gradually being replaced by paste fills worldwide, in an effort to reduce the environmental impacts of mining. However, rockfills do offer important economic advantages over paste fills, especially when there is a large stockpile of readily available waste rock. Rockfills continue to be popular in Nevada in the US for undercut drift and fill stopes, and small longhole stopes, where a quick stope turnaround is needed.

Chapter 8 opens up the discussion to other uses of mine fills including backfilling coal mines, using fills to reduce surface subsidence, backfilling open pits after closure, and co-disposal of municipal and mining wastes. Unlike returning mine wastes underground, these methods require extensive geochemical characterization of the waste products and the receiving environment, in order to prevent contamination. In fact, regulatory and public concerns about contaminant transport have prevented many worthwhile such projects from proceeding in the US and Canada.

The latter part of the chapter gives an overview of some of the key aspects of cemented aggregate fills including the ideal grading, fill quality control parameters, fill performance measurements and monitoring.

Chapter 9 introduces two new aspects of mine filling rarely dealt with in the literature; that is risk management and environmental risks. The chapter presents an excellent framework for quantifying and assessing backfill risks in a mining environment, based on several Australian and New Zealand standards. The reality of the mining business today is that risks translate into real costs, and they must be quantified in assessing the total cost of a backfill system. Such a system of capitalizing risks lends itself to highlighting the cost effectiveness of paste backfill when the potential risks of surface disposal of tailings are weighed against the cost of underground disposal.

And finally Chapter 10 deals with emerging technologies and current research. This chapter gives an overview of the papers presented at the last 3 Minefill series of Symposia, along with comments from international practitioners on future trends in the industry.

As has been noted by the editors, each chapter in the Handbook could ideally form the basis for an entire textbook. As such the handbook tries to strike a balance between the topics needed by mine fill operators and engineers, and extended topics that go beyond the scope of the book. Some of the topics that readers may wish to explore beyond the handbook include limit equilibrium design of stable fill exposures for undercut sills and other typical geometries, backfill instrumentation, backfill quality control monitoring and quality assurance programs, cement optimization, and costing of backfill systems.

The real value in this handbook is that it is authored by practitioners in the field and thus contains a wealth of practical knowledge and real operational experience. This is in contrast to some reference texts which have been authored by researchers and universities and thus tended to be much more theoretical than practical.

The breadth of topics covered by this handbook make it an ideal reference manual for mining engineers, and the inclusion of a comprehensive overview of the basic material properties, geomechanics and fluid mechanics aspects of mine fills makes this book an ideal teaching tool for universities and mining schools.