

PIERO SEMBENELLI
CONSULTANT

15 A. da Giussano 20145 Milano
1 Nirone 20123 Milano

Proceedings of the Conference on

Grouting In Geotechnical Engineering

Edited by Wallace Hayward Baker

Sponsored by the Geotechnical Engineering Division
of the American Society of Civil Engineers

in cooperation with
ASCE/AIME Underground Technology Research Council
Louisiana Section, ASCE
New Orleans Branch, ASCE

Monteleone Hotel
New Orleans, Louisiana
February 10-12, 1982



Published by the
American Society of Civil Engineers
345 East 47th Street
New York, New York 10017

The Society is not responsible for any statements made or opinions expressed in its publications.

Copyright © 1982 by the American Society of Civil Engineers.
All Rights Reserved
Library of Congress Catalog Card Number 81-71798
ISBN 0-87262-295-9
Manufactured in the United States of America

PREFACE

Since 1960, the Geotechnical Engineering Division has sponsored specialty conferences at two-year intervals. These highly successful meetings have covered a wide range of geotechnical subjects and have made significant contributions to engineering literature. Most of the specialty conferences have been organized by task committees appointed specifically and solely for such purpose. This, the first specialty conference to deal exclusively with grouting, has been organized by the Grouting Committee of the Geotechnical Engineering Division. Committee members involved during the past three years in the various tasks required include:

WALLACE HAYWARD BAKER, Co-Chairman
Hayward Baker Company, Odenton, MD

R. H. KAROL, Co-Chairman
Rutgers University, New Brunswick, NJ

PETER P. ABERLE
Bureau of Reclamation, Denver, CO

JOHN A. ALBRITTON
Corps of Engineers, Omaha, NE

RICHARD M. BERRY
Penetron/BPR, Knoxville, TN

G. WAYNE CLOUD
Stanford University, Stanford, CA

RAY COPE
Grouting Consultant, Lincoln, NE
(formerly Soil Conservation Service, ret.)

JAMES H. COULSON
Tennessee Valley Authority, Knoxville, TN

EDWARD D. GRAF
Pressure Grout Company, South San Francisco, CA

JEAN-YVES PEREZ
Woodward-Clyde Consultants, Chicago, IL

BIRGER SCHMIDT
Parsons, Brinckerhoff, Quade & Douglas, Inc.
San Francisco, CA

JAMES WARNER
Consulting Engineer, Mariposa, CA

JOSEPH P. WELSH
Hayward Baker Company, Odenton, MD

It has been almost two decades since the last publication of proceedings from a grouting conference. The 63 papers included in these proceedings come from 12 different countries and deal with the pertinent advances in grouting materials and technology that have occurred throughout the world over the past two decades.

A post-conference discussion volume will be published with distribution to registered attendees. In addition, the Grouting Committee welcomes communication from anyone with a contribution to make to the advancement of the grouting profession.

Wallace Hayward Baker
ASCE Grouting Conference Committee Co-Chairman

R. H. Karol
ASCE Grouting Conference Committee Co-Chairman
ASCE Grouting Committee, Chairman

CONTENTS

Background Talk: Cement Grouting for Dams	
Adam Clive Housby	1

SESSION I MATERIALS FOR CEMENT AND MORTAR GROUTS

Design of Cement Based Grouts	
G. S. Littlejohn	35
Testing of Optimum Pumpability of Concrete	
R. O. Lane and J. F. Best	49
Effects of Mixing on Bentonite Slurries and Grouts	
Stephan A. Jefferis	62
Ultra Fine Grouting Material	
Masao Shimoda and Hiroshi Ohmori	77

SESSION II DAM GROUTING TECHNOLOGY

Grouting of the Karstic Caves with Clay Fillings	
Zhang Zuomei and Huo Pinshou	92
Monitoring of Grout Leaching at Three Dams Curtains in Crystalline Rock Foundations	
Miron B. Petrovsky	105
Grouting Plant & Equipment	
A. W. Gourlay and C. S. Carson	121
Remedial Drilling and Grouting of Two Rockfill Dams	
Robert C. Fox and Martin C. Jones	136
Special Grouting at Tarbela Dam Project	
John Lowe, III and T. C. Sandford	152

SESSION III APPLICATIONS OF DAM GROUTING TECHNOLOGY

A Cut Off in Rock and Alluvium at Asprokremmos Dam	
L. A. Bell	172

Remedial Grouting at Hilton Falls Dam, Canada Michael G. Jefferies and John B. Davis	187
Foundation Grouting of the LG-2 Main Dam La Grande Complex, Quebec Z. Aziz and J. Levay	202
Electric Lake Dam Grouting Jagan N. Gosain and John R. Kunz	217
Grouting of the Foundation of Dartmouth Dam Brian Raymond Cole	233
Chicoasen Project Grouting and Drainage System Armando Rabago	246

SESSION IV DESIGN AND CONTROL FOR DAM GROUTING

Cement Grouting Practices U.S. Army Corps of Engineers John A. Albritton	264
Cement-Bentonite Grouting for Dams Don U. Deere	279
Aspects of Rock Grouting Practice on British Dams D. A. Bruce	301
Optimum Water: Cement Ratios for Rock Grouting Adam Clive Housby	317
Grouting at Clarence Cannon Dam: A New Approach Michael J. Klosterman, Michael M. Easterly and Nels G. Jahren	332
Background Talk: The State of Grouting in the 1980's Claude Caron	346

SESSION V CHEMICAL GROUTS MATERIALS

Chemical Grouts and Their Properties R. H. Karol	359
A New Grouting Material of Non-alkaline Silica Sol Masaru Hoshiya, Shunsuke Shimada, Hitaka Kanematu and Kenji Kayahara ..	378
Injectite-80 Polyacrylamide Grout Richard M. Berry	394
Polyurethane Grouting in Hydraulic Engineering Liu Jiacai, Wang Baochang, Cui Wenguang, Guo Yuhua and Cheng Hesheng ..	403
Performance Characteristics of Acrylate Polymer Grout William J. Clarke	418

SESSION VI
BEHAVIOR OF CHEMICALLY GROUTED SOIL

Properties of Chemically Grouted Sand at Locks and Dam No. 26 Richard Davidson and Jean-Yves Perez	433
Creep Behavior of Silicate Grouted Sand Roy H. Borden, Raymond J. Krizek and Wallace Hayward Baker	450
Long Term Aging Effects on Chemically Stabilized Soil Thomas E. Graf, G. Wayne Clough and James Warner	470
Effective Stress-Strain-Strength Behavior of Silicate-Grouted Sand Raymond J. Krizek, M. Adel Benitayf and Dimitrios K. Atmatzidis	482
Mechanical Behavior of Silicate-Grouted Soils Birgit U. Stetzler	498

SESSION VII
CHEMICAL GROUTING TECHNOLOGY AND APPLICATIONS

Planning and Performing Structural Chemical Grouting Wallace Hayward Baker	515
Injection and Distribution of Silicate Grout in Sand Talat A. Bader, Raymond J. Krizek and Wallace Hayward Baker	540
Seepage Control with Chemical Grout R. H. Karol	564
Soil Stabilization by Grouting on Baltimore Subway Edward J. Zeigler and John L. Wirth	576
Chemical Grouting for Construction of 8-Foot Diameter Tunnel Through "Little Italy", Baltimore, Maryland S. Murray Miller, Joseph P. Welsh, Manu Patel, Howard Waugh and Kwok Leung Li	591

SESSION VIII
GROUTING FOR TUNNELS, SHAFTS, AND MINES

Grouting Techniques Used in Deep South African Mines Hans K. O. Dietz	606
Cementing Steel Linings in a Deep Blind-Bored Shaft Ray W. Amstutz and James E. Hawkins	621
Squeeze Grouting Unstable Ground in Deep Tunnels David A. Greenwood and M. Thomas Hutchinson	631
Grouting Methane Drainage Holes in Coalbeds Joseph Cervik	651
Hydrogeological Assessment and Grouting at Selby James C. Black, C. Alan Pollard and Graham P. Daw	665

SESSION IX
ALTERNATIVE GROUTING TECHNOLOGY (A)

A Unique Underpinning of Soil Solidification Utilizing Super-High Pressure Liquid Jet M. Shibasaki and S. Ohta	680
Compaction Grouting — The First Thirty Years James Warner	694
Pressure Injection Grouting of Landfills Using Lime and Fly Ash James R. Blacklock, R. C. Joshi and P. J. Wright	708
Lifting and Leveling Heavy Concrete Structures John C. King and Eduardo W. Bindoff	722
Grouting Method by Using Flash-Setting Grout T. Tokoro, S. Kashima and M. Murata	738

SESSION X
TESTING AND CONTROL FOR GROUTING

Matrix Evaluation of Structural Grouting of Rock Richard A. Millet and Richard Engelhardt	753
Electric Monitoring of Grouting Michael G. Jefferies, Brian T. Rogers and Denys W. Reades	769
Grout Monitoring and Control P. J. Huck and M. J. Waller	781
Multiple Hole Grouting Method Reinhard E. Mueller	792
New Laboratory Techniques to Test Grouted Fractured Rock Gerard Ballivy and Pierre Niemants	809
Lime Slurry Glaze Method of Soil Testing James R. Blacklock	822

SESSION XI
ALTERNATIVE GROUTING TECHNOLOGY

Cement Grouts in Offshore Steel Structures John Colin Woodward	836
Highway Grouting - A Permeable Grout Provides Drainage Below a Concrete Pavement James M. Polatty	849
Pre-Stress Grouting of High Pressure Waterways Robin R. W. Harris	859

Use of Grouting in Caisson Construction	
Clyde N. Baker, Jr., Francisco A. Echevarria and John P. Gnaedinger	874
Thorough Grouting Can Reduce Lining Costs in Tunnels	
G. Dan Johnson	892

SESSION XII
APPLICATIONS OF GROUTING TECHNOLOGY

Swedish Valve Tube Grouting	907
Bruce A. Lamberton	
Compaction Grouting for Foundation Stabilization	923
Alan N. Stilley	
Soil Modification for Relocating Die Forging Operations	938
Antal Partos, Richard D. Woods and Joseph P. Welsh	
Consolidation Grouting at an Existing Navigation Lock	959
Thomas L. Neff, John W. Sager and James B. Griffiths	
Grouting Halts Chemically Induced Settlement	974
R. D. Hinkle, Jr. and B. C. Yen	
Grouting Caverns and Soft Zones by Concrete Pumps	987
C. A. Ortiz-Suarez and J. C. Agrelot	
A Digest of Typical Cement Grouting Takes	1000
Adam Clive Housby	
Subject Index	1015
Author Index	1017