## Grouting Theory and Practice

E. Nonveiller

Grškovića 28, 41000 Zagreb, Yugoslavia



**ELSEVIER** 

Amsterdam — Oxford — New York — Tokyo 1989

## CONTENTS

| 1. | INTRODUCTION  |
|----|---|
| 2. | PROPERTIES OF SOILS AND ROCKS   |
|    | 2.1. Geology of site  |
|    | 2.31. Lugeon's method for permeability measurement  |
| 3. | GROUTING SUSPENSIONS, SOLUTIONS AND RESINS  |
|    | 3.1. Suspensions  |
|    | 3.2. Materials for suspensions  |
|    | 3.21. Portland cement   |
|    | 3.23. Sand and fillers  |
|    | 3.3. Properties of grout suspensions  |
|    | 3.31. The stability of grout suspensions  |
|    | 3.4. Physical properties of injected grouts   |
|    | 3.41. The strength gain of injected grouts  |
|    | 3.43. The resistance of injected grout to erosion   |
|    | 3.45. The volume stability of injected grouts   |
|    | 3.51. Viscosity   |
|    | 3.53. The gel time  |
|    | 3.55. Economic aspects  |
|    | 3.56. Sodium silicate grouts       66         3.57. Acrylamide grouts       67         3.58. Other chemical grouts       67 |
|    | 3.59. Foams   |

| 4.    | GRO  | OUTING TECHNOLOGY  |
|-------|------|--|
|       | 4.1. | Grouting compounds   |
|       |      | 4.21. Compounds for injecting fissures and joints  |
|       |      | 4.22. Plugging of wide spaces and caverns  |
|       |      | 4.23. Grouting compounds for granular materials  |
|       |      | 4.24. Grouting compounds for other applications  |
|       | 4.3. | The grouting pressure  |
|       |      | The injection process  |
|       |      | Grouting alluvial deposits   |
| 5.    | DRI  | ILLING AND INJECTION PLANT AND EQUIPMENT   |
|       | 5.1. | Drilling machinery and accessories   |
|       |      | Batching and mixing equipment  |
|       |      | Injection pumps  |
|       |      | Injection lines and accessories  |
|       |      | Recording instruments  |
|       |      | The grouting plant   |
| 6.    |      | E GROUT CURTAIN  |
| 77.70 |      | Seepage through the dam foundation   |
|       |      | Design parameters for grout curtains   |
|       | 0.2. | 6.21 The effect of the grout curtain on the hydrodynamic potential field 124   |
|       | 63   | Injection of grout curtain to required permeability standard   |
|       | 0.5. | 에 있는 것이 없는 것이 되는 것이 같아. 그런데  |
|       |      | 6.31. Number of grout hole rows  |
|       |      | 6.32. Selection of grout compound  |
|       | 6.4. | Technical specifications for curtain grouting  |
|       |      | 6.41. Digest of Technical Specifications for curtain grouting works  |
|       |      | I. Types and volume of works, II. Drilling and grouting plant and equipment, III. Grouting materials, Cement, Bentonite, Clay, Sand, additives, Water, IV. Drilling works, V. Permeability testing, VI. Grouting, VII. Payment of works  |
|       | 6.5. | Observation of grout curtain performance   |
|       | 6.6. | Examples of grout curtains   |
|       |      | 6.61. Grout curtains in karstified rock regions  |
|       |      | Grout curtain of the Peruča Dam, Grout curtain of the Sklope Dam, Grout curtains of the Buško Blato reservoir, Left reservoir rim curtain at Keban Dam, Grout curtain of the Kao Laem Dam, Grout curtain of the El Cahon Arch Dam, Conclusion on grout curtains in karstified rock |
|       |      | 6.62. Grout curtains in diverse rocks  |
|       |      | Grout curtain through masonry of the Aswan Dam on the Nile,<br>Aslantas grout curtain in Flysh   |
|       |      | 6.63. Grout curtains in alluvial soils   |
|       |      | Sad el Aali Dam grout curtain in the Nile alluvium,<br>Asprokremmos Dam alluvial grouting  |
|       | 6.7  | Parameters of various grout curtains   |
|       |      |  |

| 7. | CONTACT AND CONSOLIDATION GROUTING   | 189 |
|----|--|-----|
|    | 7.1. Scope and application of consolidation and contact grouting   | 189 |
|    | 7.2. Contact grouting  | 189 |
|    | 7.3. Consolidation grouting  | 192 |
|    | 7.4. Case records of consolidation grouting  | 193 |
|    | 7.41. Rock improvement in dam foundations  | 193 |
|    | 7.42. Contact and consolidation grouting around tunnel linings   | 197 |
| Q  | PRESTRESSING OF ROCK AND LINING OF PRESSURE TUNNELS  |     |
| 0. | BY GROUTING  | 203 |
|    | 8.1. Rock anchors  | 203 |
|    | 8.2. Tunnel lining prestressed by grouting   | 215 |
| 9. | LIFTING AND LEVELLING OF STRUCTURES BY GROUTING  | 225 |
|    | 9.1. Theoretical background  | 226 |
|    | 9.2. Grouting compounds  | 228 |
|    | 9.3. Grouting procedures for compaction grouting   | 228 |
|    | 9.4. Examples of the lifting and levelling of buildings  | 230 |
|    | The Emil Coking Plant in Essen, Hydroelectric Power Plant Hessigheim,<br>Leaning grain elevator, Leaning silo cells, Mine hoist headframe,<br>Foundation of Ninian Platform in the North Sea |     |
| 10 | SYMBOLS  | 239 |
| 11 | BIBLIOGRAPHY   | 241 |
| 12 | 2.GLOSSARY AND INDEX   | 247 |
|    | 12.1. Glossary   | 247 |
|    | 12.2. Index  | 248 |