

Contents

List of figures

List of figures

Foreword

Acknowledgments

About the authors

Introduction

1. An Overall Introduction to Concrete Face Rockfill Dams-CFRD

- 1.1 A panorama of CFRDs in the world
- 1.2 Important events related to CFRD
- 1.3 CFRD in seismic areas – a historical event
- 1.4 High dams in a near future
- 1.5 Thoughts on very high CFRDs

2. Design criteria for CFRDs

- 2.1 Introduction
- 2.2 Rockfill embankment
- 2.3 Water flow through rockfill and leakage
- 2.4 Stability
- 2.5 Toe slab or the plinth
- 2.6 Concrete face slab
- 2.7 Perimeter joint
- 2.8 Parapet wall and camber
- 2.9 Other impervious alternatives
- 2.10 Construction
- 2.11 Instrumentation
- 2.12 An overall conclusion

3. Typical cross sections

- 3.1 International nomenclature
- 3.2 Evolution of compacted CFRD
- 3.3 Case histories
 - 3.3.1 *Cethana (Australia, 1971)*
 - 3.3.2 *Alto Anchicayá (Colombia, 1974)*
 - 3.3.3 *Foz do Areia (Brazil, 1980)*
 - 3.3.4 *Aguamilpa (Mexico, 1993)*
 - 3.3.5 *Campos Novos (Brazil, 2006)*
 - 3.3.6 *Shuibuya (China, 2009)*
 - 3.3.7 *Tianshengqiao 1 (China, 1999)*

- 3.3.8 *Mohale (Lesotho, Africa, 2006)*
 - 3.3.9 *Messochora (Greece, 1996)*
 - 3.3.10 *El Cajón (Mexico, 2007)*
 - 3.3.11 *Kárahnjúkar (Iceland, 2007)*
 - 3.3.12 *Bakún (Malaysia, 2008)*
 - 3.3.13 *Golillas (Colombia, 1978)*
 - 3.3.14 *Segredo (Brazil, 1992)*
 - 3.3.15 *Xingó (Brazil, 1994)*
 - 3.3.16 *Pichi Picún Leufú (Argentina, 1995)*
 - 3.3.17 *Itá (Brazil, 1999)*
 - 3.3.18 *Machadinho (Brazil, 2002)*
 - 3.3.19 *Antamina (Peru, 2002)*
 - 3.3.20 *Itapebi (Brazil, 2003)*
 - 3.3.21 *Quebra-Queixo (Brazil, 2003)*
 - 3.3.22 *Barra Grande (Brazil, 2005)*
 - 3.3.23 *Hengshan (China, 1992)*
 - 3.3.24 *Salvajina (Colombia, 1983)*
 - 3.3.25 *Puclaro (Chile, 2000)*
 - 3.3.26 *Santa Juana (Chile, 1995)*
 - 3.3.27 *Mazar (Ecuador, 2008)*
 - 3.3.28 *Merowe (Sudan, 2008)*
- 3.4 Conclusions

4. The Mechanics of Rockfill

- 4.1 Introduction
 - 4.2 Rockfill embankments evolution
 - 4.3 The compacted rockfill
 - 4.4 Rockfills geomechanic properties
 - 4.5 Shear strength
 - 4.6 Compressibility
 - 4.7 Collapse
 - 4.8 Creep
 - 4.9 Rockfills as construction materials
- Appendix 4.1 – Machadinho D

5. Stability

- 5.1 Static stability
- 5.2 Safety factors for typical rockfills embankments
- 5.3 Stability in seismic areas
- 5.4 Dynamic analysis
- 5.5 Seismic design selection
- 5.6 Slope stability
- 5.7 Permanent deformations

6. Seepage through rockfills

- 6.1 Introduction
- 6.2 Theories on flow through rockfills
- 6.3 Critical aspects for stability
- 6.4 Some historical precedents
- 6.5 Leakage measured in CFRDs
- 6.6 Design of CFRDs for throughflow control
- 6.7 The reinforced rockfill

7. Foundation treatment

- 7.1 Plinth foundation
- 7.2 Plinth stability
- 7.3 Foundation transitions
- 7.4 Rockfill foundation
- 7.5 Grouting

8. Plinth, slab and joints

- 8.1 Plinth
- 8.2 Slab
- 8.3 Reinforcement design
- 8.4 Crest parapet wall and freebord
- 8.5 Fissures, cracks and failures – Treatments
- 8.6 Drainage near the plinth

9. Instrumentation

- 9.1 Introduction
- 9.2 Monitoring parameters
- 9.3 Monitoring and maintenance care
- 9.4 Final considerations

10. CFRDs Performance

- 10.1 Introduction
- 10.2 Settlements
- 10.3 Correlations between settlements, dam height and valley shape
- 10.4 Horizontal displacements
- 10.5 Combined movements
- 10.6 Face deflection
- 10.7 Vertical compressibility Modulus (EV) and transversal modulus (ET)
- 10.8 Tri-dimensional displacements
- 10.9 Conclusions

11. Numerical analysis and its applications

- 11.1 Introduction

- 11.2 Engineering properties of rockfill material
- 11.3 Rockfill material constitutive models
- 11.4 CFRDs numerical analyses methods
- 11.5 Application of numerical analyses on CFRDs
- 11.6 Closing remarks
- 11.7 Numerical analyses applied to Brazilian CFRDs10 CFRDs Performance

12. Construction features

- 12.1 Introduction
- 12.2 General aspects
- 12.3 Plinth construction
- 12.4 Excavation
- 12.5 Concrete construction
- 12.6 River diversion
- 12.7 Embankment construction
- 12.8 Fill construction
- 12.9 Slab construction
- 12.10 Outputs

References

Colours platers