

## CONTENTS

PREFACE	5
RESUME	7
1. INTRODUCTION	9
2. THE DAM AND THE DAM SITE	11
2.1 General information	
2.2 Geological conditions	
2.3 Design, construction and operation of the dam	
2.4 Monitoring results and the performance of the dam	
3. CONCEPT OF THE STABILITY STUDY AND THE MODELLING CONCEPT	18
3.1 Study of the stability of the dam	
3.1.1 Objectives	
3.1.2 Preparatory phase	
3.1.3 Analysis of sources	
3.2 Modelling concept	
4. NUMERICAL CODE AND ALGORITHMS	20
4.1 CRISP-PATH FEM code	
4.2 Path dependent elastic-plastic constitutive model	
4.3 Strength reduction method	
4.4 Multiface viscoplastic flow	
4.5 Calibration procedure	
5. TWO-DIMENSIONAL LOCAL MODELS	23
5.1 Back analysis and stability assessment of the dam section on the weak marly shale	
5.1.1 Computational model and its calibration (Phase 1a)	
5.1.2 Stability assessment (Phase 1b)	
5.1.3 Thermal effects (Phase 1c)	
5.2 Back analysis and stability assessment of the dam section on the teschenite	
5.2.1 Computational model and its calibration (Phase 2a)	
5.2.2 Stability assessment (Phase 2b)	
6. TWO-DIMENSIONAL REGIONAL MODELS	34
6.1 Formation of the valley and rheological model of the weak marly shale (Phase 3a)	
6.1.1 Geological model of the valley	
6.1.2 Computational models of the valley	
6.1.3 Solution strategy	
6.1.4 Results	
6.2 Stability of the right bank of the valley during construction of the dam (Phase 3b)	
6.3 Viscoplastic flow of the weak marly shale during operation of the dam (Phase 3c)	

7.	THREE-DIMENSIONAL REGIONAL MODEL OF THE DAM AND ITS FOUNDATION	43
7.1.	3D computational models	
7.2.	Simulation of the construction of the dam and the first filling of the reservoir	
7.3.	3D viscoplastic flow of the weak marly shale during operation of the dam	
7.4.	Stability assessment	
8.	CONCLUSIONS AND ISSUES OF THE MODELLING WORK	53
9.	UNCERTAINTIES AND RISKS	56
9.1.	Observed phenomena and possible treatment	
9.2.	Consequences of the dam movements	
9.3.	Consequences of the uplift redistribution in the bedrock	
9.4.	Stability of the right bank of the valley and the supporting embankment	
10.	RECOMMENDATIONS	58
11.	REFERENCES	59
	APPENDIX A: PATH DEPENDENT CONSTITUTIVE MODEL	61
	APPENDIX B: MULTISURFACE VISCOPLASTIC FLOW	63