Research and Development Thesis

Assessing the risk of a large hydropower dam failure

By: Gabrielle Hosein

Institute Supervisors: Dr. Petrissa Eckle and Dr. Peter Burgherr, Paul Scherrer Institut

Academic Supervisor: Dr. Tamas Kramer, Budapest University of Technology and Economics

Submitted in partial fulfillment of the requirements for the degree of Master of Science in Hydroinformatics and Water Management, EuroAquae

August 2011

MSc. Project Title: Assessing the risk of a large hydropower dam failure

Hosting Institution: Paul Scherrer Institut, Villigen, Switzerland

Abstract: Dam break analysis is an area of ongoing, extensive research. As the energy sector shifts to incorporate safe and sustainable sources for a growing global population, there is an increasing focus on low carbon technologies, hydropower being one of them. Hydropower dams are frequently constructed upstream of population centres, imposing risks to inhabitants downstream.

The goal of the following study is to combine the flow characteristics of ten unique dam break scenarios with empirical modeling principles to estimate associated loss of life. The results will contribute to a comparative risk assessment of the hydropower energy chain.

A two-dimensional model for a large hydropower dam is developed to simulate the ten dam break scenarios. Three empirical formulas with varying calculation methods are used to estimate loss of life. The results are compared to find the method which realistically summarizes the number of fatalities for each dam break scenario. The risk analysis is enhanced by estimations of the probability of failure on the individual dam.

Keywords: hydropower dam failure, hydraulic modeling, risk analysis, probability of dam failure, flood hazard

PREFACE

This research thesis has been submitted in partial fulfillment of the requirements for the MSc. program entitled: EuroAquae Hydroinformatics and Water Management. The program is sponsored by the European Commission and consists of three course based semesters at a combination of the following participating universities:

- Newcastle University (Newcastle Upon Tyne, UK)
- Technical University of Catalonia (Barcelona, Spain)
- University of Nice – Sophia Antipolis (Nice, France)
- Brandenburg University of Technology (Cottbus, Germany)
- Budapest University of Technology and Economics (Budapest, Hungary)

The fourth and final semester of the program involves a research thesis. The thesis was carried out during a three month internship at the Paul Scherrer Institut located in Villigen, Switzerland. The following thesis will contribute to the long-term project on "Comprehensive Assessment of Energy Systems" launched by the Paul Scherrer Institut (PSI) and the Swiss Federal Institute of Technology (ETH) in Zurich.

AFFIDAVIT

I confirm that I have written the following thesis on my own. I have not made use of any sources and means other than those stated and cited. This thesis has not been handed into any university or educational institution, other than the EuroAquae consortium and the Paul Scherrer Institut.

Gabrielle Hosein

ACKNOWLEDGEMENTS

I offer my sincerest gratitude to my supervisors Dr. Petrissa Eckle and Dr. Peter Burgherr, for the opportunity, for their support, knowledge and patience, and for allowing me the room to work in my own way.

I am indebted to Patric Rousselot, from ETHZ, for his encouragement and technical support.

I would also like to thank the EuroAquae professors, especially Dr. Tamas Kramer for his knowledge and support.

I would like to express a sincere thanks to my mentor and friend, Dr. David Palmer for his guidance and belief in me.

I am grateful to have the motivation and support of my close friends, especially: Shaker, Christine, Thipphavanh, Michael and Veronika. And to my EuroAquae friends who made life on the move exciting.

Last but not least, I dedicate this thesis to my family. To my grandmother Cecilia Clarke-Henwood, who is a constant source of inspiration and strength. To my parents, Ashmead and Mercedes Hosein, who have always shown endless support and encouragement. And to my brothers, who always make me laugh.