

# **ICOLD Proceedings series**

**ISSN (print): 2575-9159**

**ISSN (Online): 2575-9167**

**Book Series Editor:**

**ICOLD / CIGB (International Commission on Large Dams /  
Commission Internationale des Grands Barrages)**

**Paris, France**

**Volume 2**

PROCEEDINGS OF THE ICOLD 2019 SYMPOSIUM  
(OTTAWA, CANADA, 9-14 JUNE 2019) / UN MONDE DE BARRAGES  
DURABLES ET SÉCURITAIRES. PUBLICATIONS DU SYMPOSIUM  
ANNUEL CIGB 2019 (OTTAWA, CANADA, LE 9-14 JUIN 2019)

# Sustainable and Safe Dams Around the World

# Un Monde de Barrages Durables et Sécuritaires

*Editors – Éditeurs*

Jean-Pierre Tournier

*Hydro-Québec, Montréal, Canada*

Tony Bennett

*Ontario Power Generation, Niagara-on-the-Lake, Canada*

Johanne Bibeau

*AECOM, Montréal, Canada*



**CRC Press**

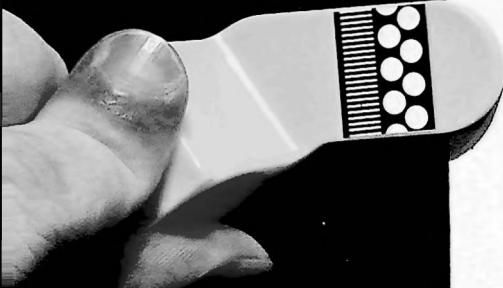
Taylor & Francis Group  
Boca Raton London New York

---

CRC Press is an imprint of the

Taylor & Francis Group, an Informa business

A BALKEMA BOOK



*CRC Press/Balkema is an imprint of the Taylor & Francis Group, an informa business*

© 2019 Canadian Dam Association. All rights reserved.  
Published by Taylor & Francis Group plc.

*Typeset by Integra Software Services Pvt. Ltd., Pondicherry, India*

All rights reserved. No part of this publication or the information contained herein may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, by photocopying, recording or otherwise, without written prior permission from the publishers. Printed in Canada.

Although all care is taken to ensure integrity and the quality of this publication and the information herein, no responsibility is assumed by the publishers nor the author for any damage to the property or persons as a result of operation or use of this publication and/or the information contained herein.

Published by: CRC Press/Balkema  
Schipholweg 107C, 2316XC Leiden, The Netherlands  
e-mail: Pub.NL@taylorandfrancis.com  
[www.crcpress.com](http://www.crcpress.com) – [www.taylorandfrancis.com](http://www.taylorandfrancis.com)

ISBN: 978-0-367-33422-2 (Set of Hbk and Multimedia)  
ISBN: 978-0-429-31977-8 (eBook)

## Table of contents / Table des matières

Preface / Préface	xxv
Letter to invitation / Lettre d'invitation	xxvii
<b>Theme 1 – INNOVATION</b>	1
Recent advancements and techniques for investigations, design, construction, operation and maintenance of water or tailings dams and spillways.	
<b>Thème 1 – INNOVATION</b>	1
Avancées et techniques récentes pour l'investigation, la conception, la construction, l'exploitation et l'entretien de barrages hydrauliques, de barrages de résidus miniers et d'évacuateurs de crues.	
<b>Hydraulic modeling / Modélisation hydraulique</b>	1
Design improvement of Bawanur dam spillway preserving the safety requirements <i>D. Stenatiu, N. Sirbu &amp; R. Cojoc</i>	3
Research on flood discharge, energy dissipation, and operation mode of sluice gate for low-head and large-discharge hydropower stations <i>Huang Wei, Tu Chengyi &amp; Zhou Renjie</i>	4
Research and application on numerical simulation of hydraulic transients in complex water conveyance system <i>G.H. Li, X.R. Chen, Y.M. Chen &amp; T.C. Zhou</i>	5
Breach modelling: Why, when and how? <i>M. Hassan, M. Morris &amp; C. Goff</i>	6
CFD modelling of near-field dam break flow <i>S. Esmaeeli Mohsenabadi, M. Mohammadian, I. Nistor &amp; H. Kheirkhah Gildeh</i>	7
Canal embankment failure mechanism, breach parameters and outflow predictions <i>H. Kheirkhah Gildeh, P. Hosseini, H. Zhang, M. Riaz &amp; M. Acharya</i>	8
Flood retention dams with full ecological passage – recent projects in Germany <i>H. Haufe</i>	9
Solving spillway geometry for three-dimensional flow <i>G.L. Coetze &amp; S.J. van Vuuren</i>	10
Investigating high flow measurements using compound gauging structures <i>A.A. Maritz, P. Wessels &amp; S.J. van Vuuren</i>	11
Scouring analysis on flip bucket spillway of Cisokan Lower Dam using experimental investigation <i>J. Zulfan, S. Lestari &amp; Y.E. Kumala</i>	12

Innovative approach to hydraulic design and analysis for Bluestone Dam primary spillway stilling basin <i>D. Moses &amp; N. Koutsounis</i>	13
Design and construction of an auxiliary labyrinth spillway for an ageing dam <i>J. Simizer, T. Madden &amp; B. Downing</i>	14
Preparation of the Mělčany dry reservoir project <i>P. Řehák, P. Holý, P. Fošumpaur, T. Kašpar, M. Králik &amp; M. Zukal</i>	15
“Hydrothermal” and season based design of dual PKW - flap gate spillway at Gage Dam <i>F. Laugier</i>	16
Design, construction and operation of offshore and onshore flood control dams in Sweden and Switzerland <i>S.-P. Teodori, A. Høgsaard &amp; H. Kaspar</i>	17
The redesign of a plunge pool slab for a temporary diversion due to dynamic pressures <i>R. Haselsteiner &amp; A. Trifkovic</i>	18
Screening level analysis of Ilisu Dam first filling impacts at Mosul Dam <i>M. Wygonik Kinkley</i>	19
Minimizing the power swing incorporating the trifurcation system of the hydropower plant <i>J. Yiu &amp; K. Lim</i>	20
Hydraulic design of stepped spillway using CFD supported by physical modelling: Muskrat Falls hydroelectric generating facility <i>J. Patarroyo, D. Danov, D. Shepherd, G. Snyder, M. Tremblay &amp; M. Villeneuve</i>	21
Predictive breach analyses for reservoir cascades <i>V. Stoyanova &amp; R. Coombs</i>	22
25 years of Gabčíkovo Water Structure System – operation, upgrade, safety and impacts on environment <i>P. Panenka, M. Bakes, I. Grundova, R. Hudec, L. Koprivova &amp; D. Volesky</i>	23
Dam and spillway rehabilitation to accommodate increased design flood: Calero Dam <i>A.R. Firoozfar, E.T. Zapel, A.L. Strain &amp; N.B. Adams</i>	24
Performance of the complex spillway structure after gate replacement - physical modelling <i>M. Broucek, M. Kralik &amp; L. Satrapa</i>	25
Levee and dam breach erosion through coarser grained materials <i>M.W. Morris, J.R. Courivaud, R. Morán, M.Á. Toledo &amp; C. Picault</i>	26
Study of bank erosion and protection measures on Subansiri River, Assam, India <i>R.K. Chaudhary, V. Anand &amp; P.C. Upadhyay</i>	27
Safety assessment of underflow stilling basin with matter element modal based on hydrodynamic loads and inspection data <i>X. Wu, Y. Chen, H. Wang, Y. Chen, Z. Liu &amp; H. Wang</i>	28
<i>Thermal and alkali-silica reaction – Concrete dams / Réaction thermique et RAG – Barrages en béton</i>	29
FE assessment of the ASR-affected Paulo Afonso IV dam <i>R.V. Gorga, L.F.M. Sanchez, B. Martin-Pérez, P.L. Fecteau, A.J.C.T. Cavalcanti &amp; P.N. Silva</i>	31

Management of ASR affected spillway structures at Kafue Gorge, Zambia <i>E. Nordström, R. Tornberg &amp; R. Kamanga</i>	32
Assessment of frost damage in hydraulic structures using a hygro-thermo-mechanical multiphase model <i>D. Eriksson, R. Malm &amp; R. Hellgren</i>	33
Refurbishment of the 120 years old inlet tower on Mundaring Weir <i>A. Gower &amp; B. Wark</i>	34
Concrete slot cutting to mitigate AAR induced concrete growth at R.H. Saunders GS <i>Dehai Zhao, L. Adegbie &amp; C. Plant</i>	35
Collapse of the terminal section of the access bridge to the intake tower of the Bezid Dam <i>I.D. Asman, C. Ban, C. David &amp; I. Tibuleac</i>	36
Assessing the structural safety of cracked concrete dams subjected to harsh environment <i>R. Malm, M. Könönen, C. Bernstone &amp; M. Persson</i>	37
Study of concrete hydroelectric facilities affected by AAR using multi-physical simulation: Consideration of the ultimate limit state <i>M.B. Ftina, E. Yıldız &amp; O. Abra</i>	38
Thermal analysis and design features of Muskrat Falls RCC North Dam <i>H. Bouzaiene, T. Smith, G. Snyder, T. Chislett &amp; J. Reid</i>	39
Design of Nimoo Bazgo project in Leh-Ladakh – A case study <i>N. Kumar, K. Deshnukhi, A. Mittal &amp; S. Dubey</i>	40
<b><i>Roller compacted concrete dams / Barrages en béton compacté au rouleau</i></b>	
Bubbled Rolled compacted concrete dam <i>E.K. Mohamed &amp; E.A. Khalil</i>	43
High performing RCC and pumpable poor CVC mix design for Monti Nieddu Dam (Italy) <i>T. Adamo, V. Aiello, S. Bonanni, R. Collarelli, F. D'Angeli &amp; C. Rollo</i>	44
Design and implementation of RCC gravity dam in HD project <i>Yang Yiwen, Deng Liangjun, Hu Lingzhi &amp; Xiang Hong</i>	45
Tallest RCC gravity dam in Lao PDR - need for high speed and solutions adopted at the Nam Ngiep 1 Hydropower <i>Y. Aosaka, T. Seoka &amp; S. Tsutsui</i>	46
Changes in forty-year-old concrete: Some observations regarding the Itaipu dam <i>C. Neumann Jr, E.F. Faria &amp; A.C.P. Santos</i>	47
Experiences for construction of RCC Dams in Sri Lanka (case study Uma Oya Project) <i>H. Mahdiloutorkamani</i>	48
Muskrat Falls North Dam – Overcoming the challenges of placing RCC in an extreme environment <i>T.P. Dolen, D. Protulipac, T. Chislett, R. Power, J. Reid &amp; J. O'Brien</i>	49
Design aspects of the highest run of the river barrage on permeable foundation of India <i>B. Joshi, R.K. Dubey &amp; M. Kumar</i>	50
RCC knowledge: How specific test can help to evaluate the real behavior of material and a better design of RCC dams <i>E. Schrader, P. Mastrotrofini, R. Saccone &amp; F. Surico</i>	51

Special solutions for mass concrete mixing aggregate handling (cooling & heating) for RCC dams <i>R. Kletsch &amp; S.J. Hegy</i>	52
<b><i>Design and numerical modelling of concrete dams I</i></b>	
<b><i>Conception et modélisation numérique des barrages en béton</i></b>	53
Best practice in preparing procurement specifications for dam protection gates <i>R. Digby &amp; K. Grubb</i>	55
Design and operational safety of ultra-deep buried large headrace tunnels of Jinping II hydropower station in China <i>Chunsheng Zhang, Xiangrong Chen, Futing Sun, Yang Zhang, Feng Wang &amp; Xiaohong Zheng</i>	56
The design of the Alto Tâmega dam in Portugal. A 106 m high double curvature arch dam <i>F. Hernando, C. Granell &amp; C. Baena</i>	57
Diversion tunnel orifices for energy dissipation during reservoir filling at Site C <i>J. Bruce, J. Croockewit, F. Yusuf, J. Nunn &amp; A. Watson</i>	58
3-D-FE models for stability analysis of concrete dams – challenges and solutions <i>K. Aldermann, U. Beetz &amp; B. Tönnis</i>	59
Biscarrués. The first hardfill dam in Spain <i>C. Granell, A. Duque, J.L. Sanchez &amp; L.J. Ruiz</i>	60
Influence of unbalanced reinforcement of abutments on long term deformation of Lijiaxia Arch Dam <i>W. Liu, J. Pan, J. Wang &amp; F. Jin</i>	61
Detailed investigations and finite element analysis of Idukki dam in India <i>V.V. Arora, B. Singh, P. Narayan &amp; B.K. Patra</i>	62
Safe design and operation of spillway gates under extreme conditions – Cold climate <i>P. Bennerstedt &amp; A. Halvarsson</i>	63
Concrete assessment and service life extension planning for Morris Sheppard Dam <i>S.S. Vaghtti, M. McClendon &amp; G.S. Lund</i>	64
Dams in 3D: The importance of considering three-dimensional response of gravity dams <i>S.L. Jones, A. Jacobs &amp; L. Martin</i>	65
Computation of safety margins of a cracked dam considering drainage efficiency in a coupled hydro-mechanical model <i>S.-N. Roth &amp; P. Léger</i>	66
Assessment of apparent cohesion at dam-rock interfaces through multiscale modeling <i>S. Renaud, T. Saichi, N. Bouaanan &amp; B. Miquel</i>	67
Reducing generation loss - operating with ice and debris on the Upper Mississippi River <i>B. Holman, A. Judd &amp; A. Peters</i>	68
Blockage of driftwood and resulting head increase upstream of an ogee spillway with piers <i>P. Furlan, M. Pfister, J. Matos &amp; A.J. Schleiss</i>	69
Design aspect of a dam without joint – Chamera-III Power Station <i>S. Chowdhury, N. Kumar, Y.K. Chaubey &amp; S.C. Joshi</i>	70

<i>Design of embankment dams / Conception des barrages en remblai</i>	71
Seepage analysis and control of core-wall rockfill dam and underground powerhouse caverns in Shuangjiangkou hydropower station, China <i>B. Duan, Z.H. He, J. Yan, J.J. Yan &amp; X.C. Peng</i>	73
Small embankment dams – benefits and problems <i>J. Riha</i>	74
Hydro-TISAR and Hydro-SEEP – innovative geophysical techniques for dam safety investigations <i>D. Campos Halas, J.L. Arsenault, B. McClement &amp; M. Situm</i>	75
Refurbishment of Ontario Power Generation's Sir Adam Beck Pump Generating Station reservoir, Niagara Falls – Design <i>S. Kam, F. Barone, M. Aydin &amp; T. Bennett</i>	76
Feedback on the innovative spillway for Crotty Dam – 25 years of performance data <i>R. Herweyem &amp; P. Southcott</i>	77
Jimmie Creek run-of-river project – geohazard and seepage control design of intake structure <i>E. de A. Gimenes &amp; R. Norman</i>	78
The failure of homogeneous dams by internal erosion -- the case of Sparmos Dam, Greece <i>G.T. Dounias &amp; M.E. Bardanis</i>	79
Impact of variable foundation conditions on the design of the Itare Asphalt Core Rockfill Dam (ACRD) in Kenya <i>L. Lopez-Ortiz, J. Bekker, D.B. Badenhorst &amp; C.R. Fynn</i>	80
Designing the grain-size distribution of reverse filters <i>I.N. Belkova, E.D. Gibyanskaya &amp; V.B. Glagovsky</i>	81
Measures to prevent internal erosion in embankment dams <i>A. Soroush &amp; P. Tabatabaie Shourijeh</i>	82
Underwater visualization for asset management and risk mitigation of dams <i>K.J. LaBry</i>	83
ICOLD Bulletin 164 on internal erosion – how to estimate the loads causing internal erosion failures in earth dams and levees <i>R. Bridle</i>	84
Case histories of tailings dam and reservoir waterproofed with a bituminous geomembrane (BGM) <i>N. Daly &amp; B. Breul</i>	85
Application of Ground-Penetrating Radar (GPR) as supporting technology for monitoring cracks at Bening Dam, East Java, Indonesia <i>N. Sadikin</i>	86
Construction of diversion culverts on compressible foundations – Large Earthfill Dams <i>M. Safavian</i>	87
<i>Numerical modeling of embankment dams / Modélisation numérique des barrages en remblai</i>	89
Reliability-based safety factors for earth dam stability calculations <i>G. Molinder, I. Ekström, R. Malm &amp; J. Yang</i>	91

Dynamic reliability analysis of earth dam's slope stability <i>S. Mousavi &amp; A. Noorzad</i>	92
Global sensitivity analysis in the design of rockfill dams <i>R. Das &amp; A. Soulaïmani</i>	93
Considering geosynthetic-reinforced piled embankments as Cemented Material Dam (CMD) foundation <i>A. Noorzad, E. Badakhshan &amp; A. Bouazza</i>	94
Sustainable design considerations in the construction of earth dams: Case study of "Yammoune" earth dam (Lebanon) <i>A. Barada, H. Haidar &amp; J. Halwani</i>	95
Numerical modelling of construction and impoundment of the Romaine-2 Asphaltic Core Rockfill Dam (Québec, Canada) <i>R. Plassart, F. Laigle, H. Longtin &amp; E. Pélugin</i>	96
Comparison of cracks and settlements in Givi Dam body in two periods, before and after earthquake (case study, Givi Dam, Iran) <i>A. Negahdar, R. Eshragi &amp; H. Negahdar</i>	97
<b>Dam foundation and geology / Géologie et fondation des barrages</b>	99
Mechanical characteristics of class-I columnar jointed basalt of Baihetan hydropower station <i>L.Q. Li, J.R. Xu, Y.L. Jiang, H.M. Zhou &amp; Y.H. Zhang</i>	101
Challenges in engineering of Pare dam on weak foundation <i>A. Mehta, D.V. Thareja &amp; V. Batta</i>	102
Innovative 3D ground models for complex hydropower projects <i>J. Weil, I. Pöschl &amp; J. Kleberger</i>	103
A story telling, dam stability issue and design review, a plea for early empirical geological/geotechnical assessment of adverse conditions in foundation <i>J.B.O. Adewumi, T. Genton, L. Frobert &amp; E.O. Ajayi</i>	104
Stabilization of abutments for dam safety: A case of Punatsangchhu-I dam with adverse geology <i>R.K. Gupta &amp; V. Tripathi</i>	105
Développement de nouveaux coulis cimentaires pour l'injection des fondations en milieu froid <i>K. Champagne, G. Touma &amp; A. Yahia</i>	106
<b>Instrumentation / Instrumentation</b>	107
Research and practice on key technologies of intelligent construction and operation of cascade hydropower stations in the river basin <i>Y.J. Tu &amp; B. Duan</i>	109
Recent remote underwater surveys: Advances in methods and technologies for structural assessments of dams and spillways <i>K.W. Sherwood</i>	110
Dam monitoring flaws and performance issues: Some thoughts and recommendations <i>M.G. de Membrillera, R. Gómez &amp; M. De la Fuente</i>	111
Reservoir Safety System (RSS) V2.0: A highly automated platform for managing the operation of reservoirs <i>K. Murray, L. Mason &amp; T. Judge</i>	112

“regObs”, a tool to share observations in safety management <i>P. H. Hiller, G. H. Midttomme &amp; R. Ekker</i>	113
The need for instrumentation; experiences on irrigation dams of Ethiopia <i>Y.K. Hassen &amp; M. Abebe</i>	114
Dam operation support system utilizing Artificial Intelligence (AI) <i>Y. Hida, H. Takiguchi, K. Kudo &amp; M. Abe</i>	115
Lessons learned in application of automated monitoring systems on hydraulic structures in Slovakia <i>M. Minarik, T. Meszaros, L. Tulak &amp; E. Bednarova</i>	116
Updating the dam safety instrumentation systems of concrete gravity dams: A case study from the Kootenay River, British Columbia, Canada <i>A.I. Bayliss, L. Hurlbut, A. Hughes, P. Hamlyn &amp; G. Johnston</i>	117
Fiber optic temperature sensors in under-documented dams <i>M.C.L. Quinn, C. Engel, T. Coleman, S. Johansson &amp; C.D.P. Baxter</i>	118
<b>Theme 2 – SUSTAINABLE DEVELOPMENT</b>	119
Planning, design, construction, operation, decommissioning and closure management strategies for water resources or tailings dams, e.g. climate change, sedimentation, environmental protection, risk management.	
<b>Thème 2 – DÉVELOPPEMENT DURABLE</b>	119
Stratégies de gestion pour la planification, la conception, la construction, l'exploitation, la mise hors service et la fermeture de barrages hydrauliques ou des barrages de résidus miniers, par exemple, changement climatique, sédimentation, protection de l'environnement, gestion des risques.	
<b>Sedimentation / Sédimentation</b>	119
Research on risk assessment of sediment depositing at the deep intakes of reservoir dams <i>C. Jiang, J.B. Sheng &amp; L.R. Fan</i>	121
The study on optimization of sediment flushing efficiency from cascade reservoirs as mitigation to the secondary impact of volcanic hazard <i>P.T. Juwono, F. Hidayat, R.V. Ruritan, A. Rianto &amp; M. Taufiqurrachman</i>	122
Experimental study on effective sediment channel with reservoir topography and morphology <i>Y. Kitamura, T. Ishino &amp; T. Okada</i>	123
Study on water diversion and sediment control of diversion type hydropower station downstream of high dam with large reservoir <i>Xiangrong Chen, Hongliang Sun, Yinin Chen &amp; Fei Yang</i>	124
Turbidity control and sediment management using sluicing tunnel at hydropower dam <i>H. Okumura, C. Onda, T. Satoh &amp; T. Sumi</i>	125
Sediment management plan in Sakawa River – the results of the first phase <i>Y. Fukuda, R. Akita &amp; K. Doke</i>	126
Study on siltation downstream of sluice and risk response measures regarding building sluice on Jiao River <i>L.H. Gao, L. Ouyang &amp; X.D. Zhao</i>	127

Filling with sediment of the reservoir "Shpilje" <i>S. Milevski</i>	128
Sediment replenishment as a measure to enhance river habitats in a residual flow reach downstream of a dam <i>S. Stähly, A.J. Schleiss, M.J. Franca &amp; C.T. Robinson</i>	129
Sustainable sediment management of small capacity Pandoh dam reservoir of Beas Satluj Link Project <i>D.K. Sharma</i>	130
Morphological modelling of sediment-induced problems at a cascade system of hydropower projects in hilly region of Nepal <i>S. Giri, A. Omer, P. Mool &amp; Y. Kitamura</i>	131
Sustainable dams in vital river systems – relevance of sediment balance <i>L. Bolzenkötter, J. Küppers &amp; R. Lothmann</i>	132
Sediment management of Nathpa Dam from heavy silt in river Satluj (India) <i>V.K. Thakur</i>	133
Study on the sediment discharge regulation of the Xiaolangdi reservoir during flood season <i>W. Ting, W. Yuanjian, Q. Shaojun, L. Xiaoping &amp; D. Shentang</i>	134
Theoretical framework of dynamic game-theory model for water and sediment allocation between cascade reservoirs and lower channel <i>X. Wang, Y. Wang &amp; E. Jiang</i>	135
Reservoir operation of Mangdechhu project and safety of the structure <i>B. Joshi, N. Kumar, K. Deshmukh, R. Baboota &amp; M. Mishra</i>	136
Change in river basin morphology due to climate change led extreme flood event <i>D.V. Singh &amp; R.K. Vishnoi</i>	137
Bener Dam as the management efforts of Bogowonto Watershed <i>M. Yushar Yahya Alfarobi</i>	138
<i>Climate change and environmental issues / Changements climatiques et environnement</i>	139
Impact of Tibet Xianghe water conservancy project to the black-necked crane and protection measures <i>Xuhang Wang, Gaojin Xu, Jian Guo, Jiayue Shi, Le Yang &amp; Ning Miao</i>	141
Comparison of reproducibility of water temperature and water temperature stratification formation by different methods in dam reservoir water quality prediction model <i>F. Kimura, T. Kitamura, Y. Tsuruta, T. Kanayama, R. Kikuchi, Y. Kitamura, T. Morikawa, Y. Okada, Y. Fukuda, T. Shoji, A. Mieno, T. Suzuki &amp; M. Kobayashi</i>	142
Development of a prediction model used in measures for reducing mold odor in dam reservoirs <i>Y. Okada, K. Shima, K. Okabe, N. Arakawa, Y. Watabe, M. Hongou &amp; H. Kushibiki</i>	143
Integrating climate change impacts in the valuation of hydroelectric assets <i>K. Pineault, E. Fournier, A. Lamy, A. Hannart &amp; R. Arsenault</i>	144
Effects of a salt-contained formation on Gotvand Reservoir, an overview on a 7-year monitoring <i>A. Zia, H. Hassani &amp; N. Kamjou</i>	145

Potential effects of the soluble formation of Gachsaran on reservoir water quality of Persian Dam reservoir <i>N. Tavoosi, A. Farokhnia &amp; F. Hooshyaripor</i>	146
Water quality management of an artificial lake, case study: The lake of the Martyrs of the Persian Gulf <i>J. Bayat, S.H. Hashemi, M. Zolfagharian, A. Emam &amp; E.Z. Nooshabadi</i>	147
The study on the impetus mechanism into resettlement due to reservoirs in China – the analyses based on WDD hydropower station's immigration <i>S. Yanguang</i>	148
Greenhouse gas emissions from newly-created boreal hydroelectric reservoirs of La Romaine complex in Québec, Canada <i>M. Demarty, C. Deblois, A. Tremblay &amp; F. Bilodeau</i>	149
Monitoring of water quality and planktonic production in Romaine estuary, three years after impoundment <i>M. Demarty, C. Deblois &amp; A. Tremblay</i>	150
Numerical simulation of sea water intrusion due to partial gate opening of the Nakdong Estuary Dam <i>Kyung Soo Jun, Jin Hwan Hwang &amp; Dong Hyeon Kim</i>	151
<b>Water management / Gestion de l'eau</b>	153
Analyzing the water supply effect of Three Gorges Reservoir on Dongting Lake during the dry season <i>L.Q. Dai, H.C. Dai, H.B. Liu, Z.Y. Tang &amp; Y. Xu</i>	155
Flexible approaches to maximum supply water level of multi-purpose dams <i>M. Möller &amp; W. Thiele</i>	156
Sustainability of water resources development: A case study from the southwest of Iran <i>A. Heidari</i>	157
Practice and optimization of the flood control operation mode for the Three Gorges Project <i>S. Li, Y. Gao, L. Xing &amp; H. Wang</i>	158
Analysis of joint optimization scheduling rules for Jinsha River cascade and Yalong River cascade <i>Zhang Hairong, Tang Zhengyang, Li Peng, Ren Yufeng &amp; Liang Zhiming</i>	159
Unknown DPRK's dam water level analysis applying artificial intelligence and machine learning method <i>J.B. Park, S.H. Lee &amp; S.J. Kim</i>	160
A study on water level management criteria of reservoir failure alert system <i>B. Lee &amp; B.H. Choi</i>	161
Optimal water resources allocation and water supply risk assessment under changing environment in the Mid-lower Hanjiang River Basin, China <i>X. Hong, L. Zhang, Y. Huang, Q. Zou, R. Zhang, X. He, L. Wang &amp; X. Hong</i>	162
Operation of large Norwegian hydropower reservoirs after quantifying the downstream flood control benefits <i>B. Glover &amp; K.L. Walloe</i>	163
The method for increasing the waterpower generation by using the storage volume for flood control in the multipurpose dams <i>H. Takeuchi, T. Ikeda, S. Nagasawa &amp; S. Tada</i>	164

National census on river and dam environments in Japan and utilization for appropriate dam management using the results <i>T. Osugi, E. Akashi, K. Yamaguchi, H. Kanazawa &amp; M. Nishikawa</i>	165
The role of streamflow forecast horizon in real-time reservoir operation <i>K. Gavahi, S.J. Mousavi &amp; K. Ponnambalam</i>	166
Assessment of increase in bed level of Ghazi-Barotha reservoir <i>K. Munir &amp; M. Zain</i>	167
Multipurpose water uses of reservoirs in Slovenia <i>N. Smolar-Žvanut, J. Meljo, N. Kodre &amp; T. Prohinar</i>	168
Reestimation of flood control storage and fixing an optimum spill <i>A.K. Paul</i>	169
<b><i>Performance and monitoring of concrete dams I</i></b> <b><i>Comportement et surveillance des barrages en béton</i></b>	
Application of Laser Doppler Vibrometry in dam health monitoring <i>M. Khun, D. Zupan, J. Lopatić &amp; A. Kryżanowski</i>	173
A guideline for ageing management of post-tensioning tendons for dam owners <i>P. Lundqvist, C. Bernstein, A. Marklund &amp; C.-O. Nilsson</i>	174
Measurement of in situ stresses in the concrete of the Cahora Bassa dam <i>L. Lamas, J.P. Gomes, A.L. Batista, E.F. Carvalho &amp; B. Matosinhe</i>	175
Evaluating the operational safety of an old run-of-river power plant <i>J.P. Laasonen</i>	176
Structural health monitoring of a buttress dam using digital image correlation <i>C. Popescu, G. Sas &amp; B. Arntsen</i>	177
Guideline for structural safety in cracked concrete dams <i>E. Nordström, R. Malm, M. Hassanzadeh, T. Ekström &amp; M. Janz</i>	178
Investigation of repeated penstock weld ruptures – Case study <i>C. Sparkes, G. Saunders &amp; M. Pyne</i>	179
Maintenance management in hydropower project: Safety aspects in Shiroro dam project in focus <i>E. Imo &amp; M. Aminu</i>	180
<b><i>Construction and rehabilitation of concrete dams I</i></b> <b><i>Construction et réhabilitation des barrages en béton</i></b>	
Restoring treatment engineering on the soleplate of stilling basin of Ankang hydropower station <i>Liu Dianhai, Wang Jue, Ding Jinghuan &amp; Yang Liu</i>	183
Anti – seepage technology and defect treatment measures of pumped storage power station <i>Lei Xianyang, Xiong Yanmei, Chen Xiangrong &amp; Sun Tanjian</i>	184
Rehabilitation works of Minab Dam spillway <i>M. Sadri Omshi, A. Amini &amp; F. Manouchehri Dana</i>	185
Underwater technologies for rehabilitation of dams: Studena case history <i>A.M. Scuero &amp; G.L. Vaschetti</i>	186
Safety by design – the new intake at John Hart generating station project <i>A.V. Maiorov, A. Kartawidjaja &amp; K. Gdela</i>	187

Development and application of various new technologies for construction of Yamba Dam <i>T. Hiratsuka, N. Yamashita &amp; T. Kase</i>	188
The application of Rubble Masonry Concrete (RMC) construction for African dams and small hydropower projects <i>R. Greyling, E. Scherman &amp; S. Mottram</i>	189
Dams in Angola, reconstruction of the Matala dam <i>C.J.C. Pontes &amp; P. Portugal</i>	190
Långströmmen Dam Safety – best practice project, an additional new spillway with an emergency radial gate and 2.5 km earth-fill dam enlargement <i>P. Kotrba, C. Sjöberg &amp; P. Bylander</i>	191
Geomembrane sealing systems for rehabilitation and upgrading concrete dams <i>D. Cankoski</i>	192
Acaray generating station life extension and modernization studies <i>D. Flores, A. Bridgeman, F. Welt, J. Aveiro, D. Benítez &amp; J. Vallejos</i>	193
<b><i>Construction and rehabilitation of embankment dams I</i></b>	
<b><i>Construction et réhabilitation des barrages en remblai</i></b>	195
Challenging conditions in the design and construction of Puah Dam in Malaysia <i>M. Afif &amp; H. Fries</i>	197
Innovations in drawoff works replacement <i>A. Bush, B. Cotter, A.L. Warren &amp; C.E. Woolcombe-Adams</i>	198
Kangaroo Creek Dam upgrade – A balanced approach to the design of upgrade works <i>P.A. Maisano, J.P. Buchanan &amp; M.B. Barker</i>	199
Refurbishment of Ontario Power Generation's Sir Adam Beck Pump Generating Station reservoir, Niagara Falls – Construction execution <i>P. Merry, B. Andruschow, V. Rombough &amp; P. Toth</i>	200
Retour d'expérience sur les mélanges chaux/ciment dans les écrans « deep soil mixing » des levées de la Loire <i>S. Patouillard, L. Saussaye, F. Mathieu, A. Le Kouby &amp; R. Tourment</i>	201
Small earth dam failure in Burkina Faso: The case of the Koumbri dam <i>A. Nacanabo &amp; M. Kaboré</i>	202
Radius analysis of the distribution mixture of sodium silicate Portland cement grouting material on various types soil of dam foundation <i>B. Risharnanda, S. Soegiarto, S. Purwaningsih &amp; A.G. Majdi</i>	203
<b><i>Investigation and monitoring of embankment dams I</i></b>	
<b><i>Investigation et surveillance des barrages en remblai</i></b>	205
Empirical shear stiffness of embankment dams <i>D.S. Park, D.-H. Shin &amp; S.-B. Jo</i>	207
Internal settlement measurements of the Romaine-3 rockfill dam <i>M. Smith &amp; J. Brien</i>	208
Study on the deformation of 200 m concrete face rockfill dam in deep foundation of narrow valley in Houziyan <i>Fuhai Yao &amp; Xing Chen</i>	209

<b>Analysis of leakage water sources around dam using water analysis <i>Jae-Seok Ha, Bong-Gu Cho, Jung-Ryeol Jang &amp; Jung-Ju Bea</i></b>	210
<b>Vegetation control on embankment dams as a part of remediation work <i>L. Demers, S. Doré-Richard &amp; D. Verret</i></b>	211
<b>The North Spur story: Two years later <i>R. Bouchard, A. Rattue, J. Reid &amp; G. Snyder</i></b>	212
<b>Means and methods of evaluating subsurface conditions and project performance at Mosul Dam <i>G. Hlepas &amp; V. Bateman</i></b>	213
<b>Investigation and treatment of buried channels in river valley projects in Himalayas <i>N. Kumar, I. Sayeed, R.C. Sharma &amp; A. Chakraborty</i></b>	214
<b><i>Spillways / Évacuateurs de crues</i></b>	<b>215</b>
<b>“You Don’t Know What You Don’t Know” <i>P. Schweiger, R. Kline, S. Burch &amp; S.R. Walker</i></b>	217
<b>Effect of boundary layer conditions on uplift pressures at open offset spillway joints <i>T.L. Wahl</i></b>	218
<b>The challenge of securing a concrete lined spillway founded on weak fractured rock containing active aquifer layers <i>D. Ryan, P. Foster &amp; B. Wark</i></b>	219
<b>High resolution spillway monitoring: Towards better erodibility models (and benchmarking spillway performance) <i>M.F. George</i></b>	220
<b>Avoiding rock erosion in the discharge channel of the Péribonka spillway <i>C. Correa &amp; M. Quirion</i></b>	221
<b>Determining geomechanical parameters controlling the hydraulic erodibility of rock in unlined spillways <i>L. Boumaiza, A. Saeidi &amp; M. Quirion</i></b>	222
<b><i>Dam safety / Sécurité des barrages</i></b>	<b>223</b>
<b>Consequences of flooding: Comparing different quantitative methods for estimating Loss of Life (LOL) <i>J. Perdikaris, W. Kettle &amp; R. Zhou</i></b>	225
<b>Regulating dams in Canada’s nuclear industry <i>G. Su &amp; G. Groskopf</i></b>	226
<b>Dam safety surveillance innovation - online remote supervision <i>S.J. Wang, J.H. Yan &amp; C.B. Ge</i></b>	227
<b>Safety vs wildlife: Managing conflicting interests during dam projects in the UK <i>T.A. Williamson &amp; P. Wells</i></b>	228
<b>Development of new simulator for training of dam operation and its future outlook <i>K. Tamura &amp; S. Kano</i></b>	229
<b>Necessity of a new public safety program around dams in Korea <i>D.H. Shin &amp; D.S. Park</i></b>	230

Study on disaster mitigation measures and emergency management of reservoir dams in strong earthquake region <i>Peng Lin</i>	231
Application of mechanical facilities support system using tablet terminals for dam management <i>T. Yoshida, Y. Matsumoto &amp; K. Sasaki</i>	232
Multifactorial studies for management of operating life of hydroelectric power plants <i>I.V. Kaliberda</i>	233
Using maturity matrices to evaluate a dam safety program and improve practices <i>R. Knott &amp; L. Smith</i>	234
Oroville in retrospect: What needs to change? <i>S.J. Rigbey &amp; D.N.D. Hartford</i>	235
A case for innovation in establishing policies, practices and standards for dam safety <i>D.N.D. Hartford</i>	236
Toward effective emergency action plan of a dam by using a network analysis <i>B.-H. Choi &amp; B. Lee</i>	237
Dam safety framework for decision-making and asset portfolio management <i>T. Salloumi &amp; S. Alrheieh</i>	238
Lessons learned from dam failures and incidents due to spillway malfunctions <i>F. Bacchus, F. Champiré, L. Deroo, F. Lemprière &amp; M. Poupart</i>	239
Importance of emergency management programs for dams and hydropower projects – Canadian perspective and Nepalese context <i>M. Acharya, C.R. Donnelly, J. Groeneveld, J.H. Rutherford, T. Bennett &amp; A. McAllister</i>	240
Design, construction and operation safety of a reinforced soil dam <i>A. Maita</i>	241
Safety measures for earth dams on basis of instrumentation data, dam site location and reservoir volume <i>F. Jafarzadeh, A. Akbari Garakani, J. Maleki &amp; M. Banikheir</i>	242
Investigation and assessment of interfaces with earthen levees <i>J. Simm, M. Roca Collert, J. Flikweert, R. Tourment, C. Neutz &amp; P. van Steeg</i>	243
A consequence-based tailings dam safety framework <i>J. Herza, M. Ashley, J. Thorp &amp; A. Small</i>	244
Risk tolerability criteria in dam safety – what is missing? <i>P. Zielinski</i>	245
Challenges and needs for dams in the 21st century <i>H. Blohm &amp; L. Deroo</i>	246
New guidelines and processes for development of additional water storage in the U.S. <i>B.N. Dwyer &amp; K.J. Ranney</i>	247
Classification of Itaipu and Three Gorges dams according to criteria of Brazilian and Chinese government agencies <i>C. Wenbo, F. Huachao, S.F. Matos, E.F. Faria &amp; M. Gayoso</i>	248

Emergency plans for large dams of hydroenergy sector in Albania <i>A. Jovani &amp; E. Qosja</i>	249
<b>Risk / Aléa</b>	251
Development of an agile risk management paradigm for under-operation hydropower dams <i>S. Yousefi, M. Rahbari &amp; N. Kheyrikhah</i>	253
Incorporation of a time-dependent risk analysis approach to dam safety management <i>J. Fluixá-Sanmartín, A. Morales-Torres, L. Altarejos-García &amp; I. Escuder-Bueno</i>	254
Integrated hydrological risk analysis for hydropower projects <i>T.H. Bakken, D. Barton &amp; J. Charmasson</i>	255
Analysis of the probability of failure of the Moste Dam <i>P. Žvanut</i>	256
Dam portfolio risk management: What we learned from analyzing seven dams owned by the Regional Government of Extremadura (Spain) <i>M. Setrakian-Melgonian, I. Escuder-Bueno, J.T. Castillo-Rodríguez, A. Morales-Torres &amp; D. Simarro-Rey</i>	257
Hazard management of Nathpa Dam (India) from Parechu lake in Tibet <i>V.K. Thakur</i>	258
Understanding risk communication approaches for dam related disasters <i>E. Yasui</i>	259
Simulation supported Bayesian network for estimating failure probabilities of dams <i>K. Ponnambalam, A. El-Awady, S. Jamshid Mousavi &amp; A. Seifi</i>	260
Conditional flood risk management <i>B. Kolen, M. Zethof &amp; B.I. Thonus</i>	261
Méthode et outil de calcul de l'aléa de rupture des digues de protection contre les inondations appliqués à la Loire <i>S. Patouillard, S. Braud, E. Durand, B. Bridoux &amp; R. Tourment</i>	262
A risk-informed approach to justify dam safety improvements <i>A.R. Firoozfar, K.C. Moen, B. McGoldrick &amp; A.N. Jones</i>	263
Risk management of new hydropower dams on the White Nile Cascade – A case study of Isimba & Karuma Hydropower Dams in Uganda <i>W. Manirakiza, F. Wasike, N.A. Rugaba, J. Semipewo, H.E. Mutikanga &amp; L. Spasic-Gril</i>	264
In praise of monitoring and the Observational Method for increased dam safety <i>S. Lacasse &amp; K. Höeg</i>	265
Bayesian Network approach for failure prediction of Mountain Chute dam and generating station <i>A. El-Awady, K. Ponnambalam, T. Bennett, A. Zielinski &amp; A. Verzobio</i>	266
Scaling risk assessment methods and approaches – From over 200 dams to site-specific studies <i>J.A. Quebbeman &amp; S.K. Carney</i>	267
<b>Design of hydropower scheme / Conception d'aménagement hydroélectrique</b>	269
Current investment in dam construction in Indonesia, forward-looking decisions <i>A. Assegaf</i>	271

Construction spillway over whole area downstream of CFRD for climate change <i>J.B. Park, S.J. Kim &amp; S.H. Lee</i>	272
Unexpected risks and work experience in construction of HPP's cascade on the Grande-de-Santiago River, Mexico <i>A. Kozyrev, A. Lashin, I. Uskov &amp; V. Uskov</i>	273
Site C Clean Energy Project, design overview <i>A.D. Watson, G.W. Stevenson &amp; A. Hanna</i>	274
Small historic dams made safe <i>D.E. Neeve &amp; M. Jenkins</i>	275
Role of dams and levees in the flood risk management in Romania <i>A. Abdulamit</i>	276
Un barrage en milieu aride <i>L. Deroo, A. Tardieu &amp; N. Ouchar</i>	277
Selection of dam type for Luapula hydropower site at Mumbotuta site CX <i>M. Simainga, R. Mukuka, M. Muamba &amp; L. Engendjo</i>	278
<b>Theme 3 – HAZARDS</b>	279
Hazards (design, mitigation and management of hazards to water or tailings dams, appurtenant structures, spillways and reservoirs (e.g. floods, seismic, landslides).	
<b>Thème 3 – RISQUES</b>	279
Mesures d'atténuation et gestion des risques liés aux barrages hydrauliques et barrages de résidus miniers, aux ouvrages annexes, aux évacuateurs de crues et aux réservoirs, par exemple, inondations, tremblements de terre, glissements de terrain.	
<i>Seismic analysis of concrete dams / Analyse sismique des barrages en béton</i>	279
Seismic safety evaluation of Tekeze arch dam <i>A. Aman, T. Manmo &amp; M. Wieland</i>	281
Design check of a river diversion inlet subjected to induced earthquake <i>F. Vulliet &amp; M. Chapdelaine</i>	282
Seismic assessment of a dam-foundation-reservoir system using Endurance Time Analysis <i>J.W. Salamon, M.A. Hariri-Ardebili, H.E. Estekanchi &amp; M.R. Mashayekhi</i>	283
Analytical study on effects of fracture energy for crack propagation in arch dam during large earthquake <i>H. Sato, M. Kondo, T. Sasaki, H. Hiramatsu &amp; H. Kojima</i>	284
Towards reliability based safety assessment of gated spillways subjected to severe loadings <i>R. Leclercq &amp; P. Léger</i>	285
Effect of joints behavior on seismic safety of concrete arch dams <i>A. Noorzad, A. Daneshyar &amp; M. Ghaemian</i>	286
A new approach for dynamic analysis of concrete gravity dam-foundation-reservoir system using different assumptions of foundation <i>A. Noorzad, P. Sotoudeh &amp; M. Ghaemian</i>	287
Dynamic analysis of a Piano Key Weir situated on concrete dams <i>M. Kashiwayanagi, Z. Cao &amp; T. Oohashi</i>	288

Comparative analysis of observed and estimated PGA for Himalayan earthquakes <i>S.L. Kapil &amp; P. Khanna</i>	289
The effect of radiation damping on seismic sliding stability of gravity dams <i>S. Guo, H. Liang, D. Li &amp; A. Zhang</i>	290
Seismic failure mechanism and safety evaluation of high arch dam-foundation system under MCE <i>D. Li, J. Tu, S. Guo &amp; L. Wang</i>	291
Vibration analysis due to frequent spilling over hollow buttress Chenderoh Dam sector gate spillway <i>M.R.M. Radzi, M.H. Zawawi, L.M. Sidek, M.H.M. Ghazali &amp; A.Z.A. Mazlan</i>	292
Comparative seismic performance of dams in Canada and China using numerical analysis and shake table testing <i>S. Li, S. Alam, A.S. Issa, T. Alam &amp; R. Austin</i>	293
Assessment of seismic design response spectra for Binaloud dam and pumped-storage project <i>S. Soleimani, A. Mahdavian, H.R. Bayati &amp; H. Bahrami</i>	294
Topographic amplification on hilly terrain under oblique incident waves <i>Z.W. Chen, D. Huang, G. Wang &amp; F. Jin</i>	295
Design of seismic reinforcement by post-tensioned anchors in Senbon Dam <i>H. Kawasaki, S. Ishifuji &amp; H. Fukumoto</i>	296
Junction and Clover Dams: Risk-based seismic evaluation of two slab-and-butress dams <i>S.L. Jones, P.E. O'Brien, S. Hughes &amp; D.D. Christopher</i>	297
The use of Ambient Vibration Monitoring in the behavioral assessment of an arch dam with gravity flanks and limited surveillance records <i>L. Hattingh, P. Moyo, S. Shaanika, M. Mutede, B. le Roux &amp; C. Muir</i>	298
State of the art nonlinear seismic analysis of an arch dam <i>G.S. Sooch, D.D. Curtis &amp; M. Likavec</i>	299
Nonlinear seismic analysis of an existing arch dam under intense earthquake <i>G.S. Sooch &amp; D.D. Curtis</i>	300
Spillway gate-reservoir interaction under earthquakes <i>N. Bouaanani, C. Gazarian-Pagé &amp; JF. Masse</i>	301
Modal identification of Karun 4 arch dam using ambient vibration tests <i>R. Tarinejad, M. Damadipour, H. Golmohammadi &amp; K. Falsafian</i>	302
DamQuake: More than just a database, a powerful tool to analyze and compare earthquake records on dams <i>E. Robbe &amp; N. Humbert</i>	303
<i>Seismic analysis of embankment dams / Analyse sismique des barrages en remblai</i>	305
Seismic analysis of Narinab earth dam and optimization of its parameters using cuckoo search <i>S.R. Anisheh, S.A. Anisheh &amp; S.H. Anisheh</i>	307
Earthquake-induced cracking evaluation of embankment dams <i>L. Mejia &amp; E. Dawson</i>	308
Seismic design aspects and first reservoir impounding of Rudbar Lorestan rockfill dam <i>M. Wieland &amp; H. Roshanomrid</i>	309

Key technologies on the harnessing project of Hongshiyuan Barrier Lake on Niulan River triggered by the 2014 Ludian earthquake <i>Z. Zang, K. Cheng &amp; Z. Yang</i>	310
Modified equivalent linear analysis of the Aratozawa dam subjected to the 2008 Miyagi earthquake <i>Z. Kteich, P. Labb��, M. Kham, V. Alves Fernandes &amp; P. Kolmayer</i>	311
Site effect study of Denis-Perron Rockfill Dam <i>D. Verret, E. P��loquin &amp; D. LeBoeuf</i>	312
Passive seismic interferometry's state-of-the-art – a literature review <i>C.T. Rodrigues, A.Q. de Paula, T.R. Corr��a, C.S. Sebasti��o, O.V. Costa, G.G. Magalh��es &amp; L.D. Santana</i>	313
<b>Geohazards / G��o-risques</b>	315
A large landslide, a reservoir and a small inspection gallery – a risk assessment, based on a well-designed instrumentation <i>F. Landstorfer, A. Blauthut &amp; E. Wagner</i>	317
Diversion tunnels – risk management confronting multiple hazards <i>W. Riemer &amp; K. Thermann</i>	318
A multi-disciplinary approach to active fault rupture risk characterization: 3D geological modelling of the Willunga fault, Mt Bold Dam, South Australia <i>S.R. Macklin, Z. Terzic, J.F. Barter, P. Buchanan &amp; M. Quigley</i>	319
The 2014 Ludian co-seismic landslide dam (Yunnan, China): Transformation from high hazard to dual purpose water conservancy and hydropower project <i>S.G. Evans, Jing Luo, Xiangjun Pei &amp; Runqiu Huang</i>	320
Review of the mudflow incident at Kafue Gorge Power Station and lessons learnt <i>M. Silwembe &amp; A. Mutawa</i>	321
Study on temporal and spatial distribution characteristics of seismic activities in Shanxi Reservoir, China <i>X.X. Zeng, T.G. Chang &amp; X. Hu</i>	322
Machine learning to predict landslide displacement in dam reservoir <i>B.B. Yang, K.L. Yin, Z.Q. Liu &amp; S. Lacasse</i>	323
Seasonal and spatial variation of seismic activity due to groundwater fluctuation in South Korea <i>Suk-Hwan Jang, Kyoung-Doo Oh, Jae-Kyoung Lee &amp; Jun-Won Jo</i>	324
<b>Theme 4 – EXTREME CONDITIONS</b>	325
Management for water or tailings dams (e.g. permafrost and ice loading, arid/wet climates, geo-hazards).	
<b>Th��me 4 – ENVIRONNEMENT EXTR��ME</b>	325
Gestion des barrages hydrauliques et barrages de r��sidus miniers, par exemple, perg��lisol et charge de glace, climats secs / humides, g��orisques.	
<b>Protection / Protection</b>	325
Riprap upgrade at WAC Bennett Dam in Canada <i>G. Wu, K. Wellburn, M. Lawrence, F. Sadeque &amp; L. Yan</i>	327

<b>Modelling of the ice load on a Swedish concrete dam using semi-empirical models based on Canadian ice load measurements <i>R. Hellgren, R. Malm &amp; D. Eriksson</i></b>	328
<b>Restoration of the upstream slope face of the Itaipu Binacional Rockfill Dam—procedures and characterization of materials <i>J. Patias, P.C. de Oliveira, D.O. Fernandes, D.P. Coelho &amp; E.F. de Faria</i></b>	329
<b>Measurement of static ice loads on dams, with varied water level <i>A.B. Foss, L. Lia &amp; B. Arntsen</i></b>	330
<b>Protection of embankments and banks against action caused by oscillatory wind waves <i>M. Spano</i></b>	331
<b>River management challenges during construction of large hydropower projects in cold climates <i>J. Malenchak, D. Damov, J. Groeneweld, G. Snyder &amp; S. O'Brien</i></b>	332
<b>Multi-purpose permanent booms – Design approach and past experience <i>R. Abdelnour &amp; E. Abdelnour</i></b>	333
<b><i>Hydrology / Hydrologie</i></b>	<b>335</b>
<b>Integrated watershed modeling to support dam safety studies <i>J. Perdikaris, W. Kettle &amp; R. Zhou</i></b>	337
<b>Applying CFD analysis to scouring river bed caused by discharge flow from the dam and estimating effectiveness of some countermeasures <i>K. Hirao, F. Watanabe, S. Ohmori, T. Tsukada &amp; T. Kurose</i></b>	338
<b>Improving prediction of river-basin precipitation by assimilating every-10-minute all-sky Himawari-8 infrared satellite radiances – a case of Typhoon Malakas (2016) <i>S. Takino, T. Tsukada, T. Honda &amp; T. Miyoshi</i></b>	339
<b>Design flood calculation using Tropical Rainfall Measuring Mission (TRMM) data <i>A. Mayangsari &amp; W. Adidarma</i></b>	340
<b>An inundation event due to the unbalance of hydraulic design scales of a dam and the downstream levee <i>Sangho Lee &amp; Yougkyu Jin</i></b>	341
<b>Hurricane Harvey rainfall, did it exceed PMP and what are the implications <i>B. Kappel</i></b>	342
<b>PMP estimation for mine tailings dams in data limited regions <i>B. Kappel</i></b>	343
<b>Hydrological modelling of ungauged catchments —a case study of the Lower Kariba Catchment <i>B. B. Mwangala</i></b>	344
<b>Sensitivity of Probable Maximum Flood estimates: Climate change, modelling, and adaptation <i>K. Sagan, K. Koenig, P. Slota &amp; T. Stadnyk</i></b>	345
<b>Risk assessment on Bibin underground dam, focusing on the effects of Cempaka tropical cyclone 2017, Indonesia <i>V. Ariyanti &amp; E.A. Frebrianto</i></b>	346
<b>Etude de régularisation du réservoir du barrage de Guitti <i>M. Kaboré &amp; A. Nombré</i></b>	347

Revisiting Creager flood peak-drainage area relationship using a Bayesian quantile regression approach <i>Jin-Guk Kim, Yong-Tak Kim, Young-Ji Moon &amp; Hyun-Han Kwon</i>	348
Identifying the role of temperature for extreme rainfalls and floods over South Korea <i>Sumiya Uranchimeg, Woo-Sik Ban &amp; Seung-Oh Lee</i>	349
Impact of climate change on the flow regime and operation of reservoirs – A case study of Bhakra and Pong dams <i>D.K. Sharma</i>	350
Climate change and waterpower – Reducing the impacts and adapting to a new reality <i>C.R. Donnelly, S. Bohrn, S. McGeachie &amp; J. Groeneweld</i>	351
Australian experience with application of Monte Carlo approach to extreme flood estimation <i>D.A. Stephens, M.J. Scorah, P.I. Hill &amp; R.J. Nathan</i>	352
<b>Theme 5 – TAILINGS</b>	353
Design, construction, operation and closure for tailings dams; recent advancements and best practice.	
<b>Thème 5 – BARRAGES DE RÉSIDUS MINIERS</b>	353
Conception, construction, exploitation et fermeture des barrages de stériles; avancées récentes et meilleures pratiques.	
Innovation in dams screening level risk assessment <i>F. Oboni, C. Oboni &amp; R. Morin</i>	355
Minimising the risk of tailings dams failures with remote sensing data <i>C. Goff, O. Gimeno, G. Petkovsek &amp; M. Roca</i>	356
Drainage and consolidation of mine tailings near waste rock inclusions <i>F. Saleh-Mbemba, M. Aubertin &amp; G. Boudrias</i>	357
Tailings dam operator training – 10 years on <i>D.M. Brett &amp; M. Rankin</i>	358
Safeguard embankment dam safety <i>R.C. Lo</i>	359
Reducing the long term risk and enhancing the closure of tailings impoundments <i>A. Adams, C. Hall &amp; K. Brouwer</i>	360
Design and operating challenges at a TSF in a high altitude, desert setting in China <i>B.P. Wrench, F.W. Gassner &amp; M. Platts</i>	361
Static liquefaction analysis of the Fundão dam failure <i>G.A. Riveros &amp; A. Sadrekarimi</i>	362
Risk mitigation by conceptual design of a tandem of tailings dams <i>D. Stematiu &amp; R. Sarghiuta</i>	363
Application status and development trend of tailings pond on-line monitoring system in China <i>X. Liu, H. Zhou &amp; J. Su</i>	364
Research and development of real-time monitoring systems for mine tailings dams <i>L. Charlebois, S. Hui &amp; C. Sun</i>	365

Enhancement of contractive tailings using deep soil mixing technique at Kittilä mine <i>E. Masengo, M.R. Julien, P. Lavoie, T. Lépine, J. Nousiainen, J. Saukkoripi, M. Piekkari &amp; J. Karvo</i>	366
Application of simplified/empirical framework to estimate runout from tailings dam failures <i>M. De Stefano, G. Nadarajah &amp; D. Bleiker</i>	367
Development of a preliminary risk assessment tool for a portfolio of TSFs with limited and uncollected data <i>R. Singh &amp; J. Herza</i>	368
Tailings dams in Romania <i>A. Abdulamit &amp; M. Grozea</i>	369
An operational perspective in the implementation of the new guidelines related to tailings management <i>M. Julien, E. Masengo, P. Lavoie &amp; T. Lépine</i>	370
Comparison of cyclic resistance ratios of tailings estimated using standard empirical methods and cyclic direct simple shear tests <i>G. Nadarajah, D. Bleiker &amp; S. Sivathayalan</i>	371
Maintenance of safety and reliability of high tailings dams in cold regions of Russia during the design phase <i>E. Bellendir, E. Filippova, O. Buryakov &amp; A. Vakulenko</i>	372
CDA technical bulletin on tailings dam breach analyses <i>V. Martin, M. Al-Mamun &amp; A. Small</i>	373
Responsible tailings management – global best practice guidance <i>C. Dunaresq &amp; M. Davies</i>	374
Staged emergency spillway development – design considerations <i>K.L. Ainsley, B. Otis &amp; E. Chong</i>	375
Tailing management – current practice in Sweden <i>S. Töyrä, A. Bjelkevik, R. Sutton, L. Lindahl &amp; J. Jonsson</i>	376
<b>Author-Index / Index des auteurs</b>	<b>377</b>
<b>ICOLD Proceedings series</b>	<b>383</b>

## Preface

The Canadian Dam Association (CDA) welcomes delegates from a large majority of ICOLD's one hundred member countries, to the 2019 Annual ICOLD Meeting and Symposium in Ottawa, Canada. These Proceedings include all papers selected by a technical review panel for their valuable contribution to knowledge on the symposium theme of Sustainable and Safe Dams Around the World.

On behalf of the organizing committee, we warmly thank the authors of the papers and the reviewers from the technical committee for their outstanding contribution to producing these publications.

Jean-Pierre Tournier,  
President, Canadian Dam Association

Tony Bennett,  
Co-Chair ICOLD 2019 Organizing Committee

Johanne Bibeau,  
Co-Chair ICOLD 2019 Organizing Committee

## Préface

L'Association canadienne des barrages (ACB) souhaite la bienvenue aux délégués qui proviennent pour une grande majorité de la centaine de pays membres de la CIGB et qui profiteront d'une participation enrichissante à l'événement de la 87<sup>e</sup> Réunion annuelle et Symposium de la CIGB qui auront lieu en 2019 à Ottawa (Canada). Ces publications comprennent tous les articles judicieusement choisis par un comité technique et répondant au thème dédié afin d'évoluer vers un monde de barrages durables et sécuritaires.

Au nom du comité organisateur, nous remercions chaleureusement les auteurs d'articles et les réviseurs du comité technique pour leur contribution remarquable à la réalisation de ces publications.

Jean-Pierre Tournier,  
Président de l'Association canadienne des barrages

Tony Bennett,  
Co-président du comité organisateur de la CIGB 2019

Johanne Bibeau,  
Co-présidente du comité organisateur de la CIGB 2019