

## DESIGN AND CONSTRUCTION OF A CUT-OFF WALL IN WARM PERMAFROST

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A cut-off wall has been designed and is currently under construction along the Back Dam of the existing tailings impoundment at Red Dog Mine, Alaska. The cut-off wall, which will be in the order of 5,000 ft long and up to 150 ft deep, when complete, is being excavated using a 40 metric ton Bauer trench cutter head mounted on a Liebherr crawler crane, in combination with a closed loop slurry pumping and de-sanding system.

The tailings impoundment is situated in an area of warm permafrost and high potential seismic activity. Design incorporated an assessment of rock jointing to define the final depth of the wall along the alignment requiring the use of plastic concrete backfill to address the concerns associated with potential cracking of the wall due to settlement and during seismic activity.

The results of the geotechnical investigation program, particularly with respect to variation in rock hardness along the wall alignment are discussed, as are the design criteria for the plastic concrete backfill, the challenges faced during construction, including scheduling of the work with the on-going dam raise activities of the mine, and the lessons learned with respect to potential productivities and selection of cutter wheels and teeth. Also described are the requirements for and advantages of utilizing a slurry boosting system to meet pumping requirements, re-design of the plastic concrete mix to consider workability and optimization of cutter teeth configurations to reduce wear through highly varied rock hardness.

**Keywords:** Cut-off wall; dam design; geotechnical investigation; trench cutter.

### Introduction

In 2002 Teck Alaska Inc. (TAK) commissioned Golder Associates Inc. (Golder) to design a Back Dam to minimize the potential for seepage at the southern end of the tailings impoundment at Red Dog Mine, Alaska. The Back Dam was to be designed for an elevation of 960 ft with a planned closure elevation of 986 ft and was to include provisions to reduce long-term seepage through the native materials and weathered bedrock.

The initial design concept included construction of a cofferdam with installation of a geomembrane liner on the upstream face of the Overburden Stockpile that would be keyed into silty native soil of relatively low permeability. A geotechnical investigation completed by Golder in 2004 found ice-rich and organic materials as well as highly fractured bedrock near the liner key-in elevations, effectively rendering this concept unacceptable.

During revision of the Back Dam design to account for the findings of the 2004 investigation, and to address the concerns of regulatory bodies, TAK requested that Golder revise the design and incorporate a cut-off through the proposed Back Dam embankment, extending to low permeability frozen bedrock to reduce the risk of long-term seepage through the native materials and weathered bedrock. Several cut-off wall options were evaluated including sheet pile installation, vibrated beams and slurry trench installation, extension of the geomembrane liner into a trench, and a cut-off wall constructed using a deep soil mixing process; specifically with the Bauer Cutter Soil Mixer (CSM). Following discussions with Golder Associates Innovative Applications (GAIA) Inc., and review of the CSM operation at a site in British



Figure 1: Back Dam Location

# Permafrost Engineering Design And Construction

**S Ashworth**



## **Permafrost Engineering Design And Construction:**

*Permafrost* National Research Council Canada. Associate Committee on Geotechnical Research, 1981      *Engineering Design and Construction in Permafrost Regions : a Review* G. H. Johnston, Kenneth A. Linell, National Research Council Canada. Division of Building Research, 1973      General Geocryology E. D. Yershov, 2004-08-19 A wide ranging and up to date review of permafrost science unique in presenting the Russian viewpoint This English edition brings the standard Russian work on geocryology to a larger readership allowing the value of the knowledge and concepts developed to be realised more widely      Advances in Multiphase Flow and Heat Transfer: Volume 1 Lixin Cheng, Dieter Mewes, 2009-12-31 Multiphase flow and heat transfer have found a wide range of applications in several engineering and science fields such as mechanical engineering chemical and petrochemical engineering nuclear engineering energy engineering material engineering ocean      *The Periglacial Environment* Hugh M. French, 2017-10-27 The Periglacial Environment Fourth Edition is an authoritative overview of the world's cold non glacial environments First published in 1976 and subsequently revised in 1996 and 2007 the text has been the international standard for nearly 40 years The Fourth Edition continues to be a personal interpretation of the frost induced conditions geomorphic processes and landforms that characterize periglacial environments Part One discusses the periglacial concept and describes the typical climates and ecosystems that are involved Part Two describes the geocryology permafrost science associated with frozen ground Part Three outlines the weathering and geomorphic processes associated with cold climate conditions Part Four provides insight into the periglacial environments of the Quaternary especially the Late Pleistocene Part Five describes some of the problems associated with human occupancy in regions that experience frozen ground and cold climate conditions Extensively revised and updated Written by an expert with over 50 years of field research Draws upon the author's personal experience from Northern Canada Alaska Siberia Tibet Antarctica Svalbard Scandinavia southern South America Western Europe and eastern North America This book is an invaluable reference for advanced undergraduates in geography geology earth sciences and environmental sciences programs and to resource managers and geotechnical engineers interested in cold regions      Arctic Climate Impact Assessment - Scientific Report Arctic Climate Impact Assessment, 2005-11-07 Arctic Climate Impact Assessment was prepared by an international team of over 300 scientists experts and knowledgeable members of indigenous communities and is the most comprehensive volume on Arctic climate change available Illustrated in full color throughout

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Selected Water Resources Abstracts , 1988      **New Accessions List** World Data Center A for Glaciology, 1983      **Oil**

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*Roads and Airfields in Cold Regions* Ted S. Vinson, James W. Rooney, Wilbur H. Haas, 1996-01-01 This state of the practice report on the design and development of roads and airfields is the eighth monograph in a series prepared by the Technical Council on Cold Regions Engineering of the American Society of Civil Engineers Previous reports in the series covered such topics as frost action and its control embankment design and arctic coastal processes This book discusses such topics as 1 Route location siting 2 frost action 3 design for permafrost conditions 4 low temperature cracking 5 maintenance 6 use of geosynthetics and 7 materials specifications and testing This monograph contributes a substantial amount of new material to the Cold Regions Engineering series

*An Introduction to Frozen Ground Engineering* Orlando B. Andersland, B. Ladanyi, 2013-11-11 Frozen Ground Engineering first introduces the reader to the frozen environment and the behavior of frozen soil as an engineering material In subsequent chapters this information is used in the analysis and design of ground support systems foundations and embankments These and other topics make this book suitable for use by civil engineering students in a one semester course on frozen ground engineering at the senior or first year graduate level Students are assumed to have a working knowledge of undergraduate mechanics statics and mechanics of materials and geotechnical engineering usual two course sequence A knowledge of basic geology would be helpful but is not essential This book will also be useful to advanced students in other disciplines and to engineers who desire an introduction to frozen ground engineering or references to selected technical publications in the field

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*Safety and Reliability* TIM BEDFORD, P.H.A.J.M. van Gelder, 2003-01-01 These proceedings contain two hundred and eighteen papers representing the work of authors from countries across the world They cover a wide range of research and

applications in safety and reliability issues that concern all types of systems processes and structures      **Advances in Analysis and Design of Deep Foundations** Murad Abu-Farsakh, Khalid Alshibli, Anand Puppala, 2017-07-11 This volume on Advances in Analysis and Design of Deep Foundations contains 22 technical papers which cover various aspects of analysis and design of deep foundations based on full scale field testing numerical modeling and analytical solutions The technical papers are 8 10 pages long that present the results and findings from research as well as practical oriented studies on deep foundations that are of interest to civil geotechnical engineering community The topics cover a wide spectrum of applications that include evaluation of the axial and lateral capacity of piles pile group effects evaluation of the increase in pile capacity with time or pile setup influence of excavation on pile capacity study the behavior of pile raft caisson foundations evaluate the bearing capacity and settlement of piles from cone penetration tests etc This volume is part of the proceedings of the 1st GeoMEast International Congress and Exhibition on Sustainable Civil Infrastructures Egypt 2017      **Ice-marginal and Periglacial Processes and Sediments** Ireneo Peter Martini, Hugh M. French, Augusto Pérez Alberti, 2011 Understanding the sediments deposited by glaciers or other cold climate processes assumes enhanced significance in the context of current global warming and the predicted melt and retreat of glaciers and ice sheets This volume analyses glacial proglacial and periglacial settings Papers include topics such as sedimentation at termini of tidewater glaciers poorly understood high mountain features and slope and aeolian deposits that have been sourced in glacial and periglacial regions and subsequently transported and deposited by azonal processes Difficulties encountered in inferring Pleistocene and pre Pleistocene cold climate conditions when the sedimentary record lacks specific diagnostic indicators are discussed The main objective of this volume is to establish the validity and limitations of the evidence that is used to achieve reliable palaeogeographic and palaeoclimatic reconstructions On the much longer geological timescale an understanding of ice marginal and periglacial environments may better prepare us for the unavoidable reversal towards cooler and perhaps even glacial times in the future

Special Report , 1987      Earthquake Hazards and Mitigation R. Ayothiraman, Hemanta Hazarika, 2008 discusses the new developments in the field of earthquake engineering and allied areas gives information about present state of the art and current practices adopted globally in prediction and mitigation of earthquake hazards explores novel and innovative methods for prediction and mitigation of hazards considering the future earthquakes for building sustainable safe infrastructures and ensuring safety of community      **Architectural Graphic Standards** The American Institute of Architects, 2007-03-30 Since 1932 the ten editions of Architectural Graphic Standards have been referred to as the architect s bible From site excavation to structures to roofs this book is the first place to look when an architect is confronted with a question about building design With more than 8 000 architectural illustrations including both reference drawings and constructible architectural details this book provides an easily accessible graphic reference for highly visual professionals To celebrate seventy five years as the cornerstone of an industry this commemorative Eleventh Edition is the most thorough and significant revision of

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