Vancouver Geotechnical Society

A Local Section of the Canadian Geotechnical Society

www.v-g-s.ca

24th Vancouver Geotechnical Society Symposium

Engineered and Natural Slopes

Friday, June 2, 2017

Registration Form

Name	
Company	
Address	
City, Province	Postal Code
Telephone	Fax
Email	

Registration	Price
Regular - before April 28	$ 200
Regular - after April 28	$ 230
Student	$ 75

For company registration, please provide the primary contact information above and attach a list of registrants with the appropriate total payment.

Please make cheques payable to the *Vancouver Geotechnical Society*

All cheques and completed registration forms to be mailed to:

Yoshi Tanaka
c/o exp Services Inc.
275 – 3001 Wayburne Drive
Burnaby, B.C. V5G 4W3

For additional information or assistance with registration, please contact:

Symposium Chair – Marc Bossé (mbosse@thurber.ca) Phone: 604-684-4384 or
VGS Treasurer – Yoshi Tanaka (yoshi.tanaka@exp.com) Phone: 604-874-1245

24th Vancouver Geotechnical Society Symposium

Engineered and Natural Slopes

Friday, June 2, 2017

Pinnacle Hotel Vancouver Harbourfront
1133 West Hastings Street, Vancouver, B.C.

ABSTRACTS

Road Reconstruction across Environmentally Sensitive Slopes on Vancouver Island
Peter Bullock, GeoStabilization International

Innovative construction techniques involving reinforced earth, soil anchors and a design build approach, not only provided economical road reconstruction, it also satisfied the long term needs of stakeholders while saving the forested riparian area along the shores of a hydro reservoir.

Waterways are common transportation corridors and desirable for homes and recreation, however the waters edge is a dynamic place. Not only is this area high in ecological value, rich with food and riparian shade, it is often actively eroding causing instability in the slopes above. The challenge of maintaining infrastructure without damaging the ecological value always proves challenging.

The road highlighted in this paper is situated within the limits of a small Village on Vancouver Island. The outer lane of this road had to be closed due to fill slope failures down to the reservoir and recreation area below. Steep slopes, high rainfall, tight budgets and multi stakeholders defined the job; Geosynthetic Confined Soil (GCS) and soil anchors fixed it.

This paper highlights how a collaborative approach between the Municipality, Power Authority, environmental consultant and designer developed the long term, low impact solution that kept the riparian zone intact.

Geogrid-reinforced Earth Structures for Transportation Projects in the Vancouver Region – Case Histories
German A. Cajigas, Tensar International Corporation
Dan MacDonald, Nilex Environmental

This paper describes several case histories of geogrid-reinforced, Mechanically Stabilized Earth (MSE) structures, including walls and slopes, that were designed and constructed for three of the major transportation projects carried out in the Vancouver Region in the last eight years: The Port Mann Highway 1 project, South Fraser Perimeter Road and Low Level Road.

The reinforced soil structures were built for grade separation purposes at multiple locations encompassing the various geotechnical environments present in the region varying from highly competent glacial soils to soft, compressible and/or liquefiable soils. The design of the earth structures had to meet performance criteria under seismic conditions and in some cases under exceptionally high loads resulting from the interaction with bridges.

The retention systems included varied configurations such as vegetated reinforced soil slopes at diverse inclinations which in many cases blended with the surrounding landscape, vertical or nearly vertical MSE walls and two-stage walls that allowed the construction of bridge abutments on compressible soils.

Post-construction performance of the reinforced soil structures has been satisfactory under the working conditions and has met the goals stablished by the project owners.

Flexible Slope Stabilization Methods in BC – Using A High-Tensile Steel Mesh to Stabilize Steep Soil Slopes
Jillian Jackson, British Columbia Ministry of Transportation Infrastructure
Andi Buechi, Geobrugg Geohazard Solutions

Over-steepened slopes above Cowichan Bay Road, in Cowichan Bay, BC have had numerous historic shallow slope failures. In recent years, re-vegetation has not been rapid enough to provide erosion protection before the winter season rainfall. As a result, sloughed material deposited on the roadway has reduced traffic to a single lane and disrupted local transportation. The British Columbia Ministry of Transportation and Infrastructure sought a long-term solution to stabilize the steep weathering glacial till slope that best protects the traveling public, and ultimately decided upon a flexible anchored mesh slope stabilization system.

Flexible mesh stabilization systems have been developed for the stabilization of over-steepened soil slopes using specialized dimensioning concepts. Current designs are largely dependent on the ability of the system to transfer forces from the high-tensile facing material to the ground anchors tied into the stable subsurface. Extensive full-scale field testing of this mesh have confirmed the performance of the complete system utilizing not only the mesh, but the anchor plate that optimizes force transfer from mesh to anchors. The system allows ground water to drain through the mesh and performs well under seismic activity due the flexible nature. The anchored mesh is combined with an erosion control mat installed underneath the mesh to prevent fine material from washing through. In addition, hydro-seed is applied to promote re-vegetation to further stabilize the surface as well as to promote an aesthetic and ‘green’ solution.

Reconciling Civil Engineering and Agronomic Practice for Natural Slope Stabilization and Revegetation
Trevor Kloeck, Synermulch Erosion Control Products

Soils in the natural environment vary widely across landscapes and are a major factor to be considered in any building project. Civil engineers from a structural perspective, and agronomists from a vegetative perspective, understand how important soils are, and have developed longstanding practices to either minimize structural impact, or maximize vegetative soil performance. Often the soil requirements of engineers and agronomists do not reconcile with each other, leading to site conditions that are sub-optimal. With design trends and regulations constantly seeking greener options, natural vegetation on slopes is becoming increasingly prevalent as a design feature. This is most prevalent in road construction, and is becoming increasingly critical in riparian zones where the preservation of habitat or quick repair of disturbed soils is essential. Synermulch and its commercialization partner Nilex, have developed a consultative approach to stabilizing and revegetating slopes where erosion control is of high importance, and revegetation must be effective. This is of particular significance in the lower mainland of British Columbia where sediment discharge into water bodies is closely monitored. This presentation will discuss the consultative approach deployed in conjunction with engineering professionals to ensure vegetation is established on natural slopes without compromising structural integrity. This often requires re-thinking how top soil and subsoil are prepared and deployed on sites, and takes into consideration species selection as a means of augmenting structural integrity. These consultative approaches often require integrative erosion control practices together including hydraulic mulches to replace erosion control blankets, and use of turf reinforcement mat technology and mulch systems in areas experiencing persistent hydraulic flow.

This paper will focus on case studies in Western Canada and Ontario that illustrate the importance of both engineering and agronomic requirements being considered together before implementation of a project. Specific emphasis will be placed on case studies in Alberta, Ontario, and specifically British Columbia where topsoil was unavailable, or nonviable due to the steepness of the slopes. All of these approaches required engineering support to be successful, and when fully implemented generated higher erosion control and vegetative performance in addition to cost savings.

Hybrid cutter soil mixing shoring system for a deep temporary excavation in Vancouver, BC

Marina Li and Nadir Ansari, Isherwood Associates
Brian Wilson, Pacific Ground Engineering

A hybrid shoring system consisting of secant king piles with Cutter Soil Mixing (CSM) infill panels was designed and constructed for temporary support of a 19.2 m deep excavation in downtown Vancouver. This temporary excavation is located adjacent to the Cambie Street Bridge off-Ramp with the shoring design required to meet a performance criteria of 20 mm of total lateral displacements. Deep soil mixing was completed up to a depth of 9.6 m through fill, peat, wood debris, and overburden consisting of clayey silt to sandy silt, and embedding into dense till with the secant king piles constructed through the dense till extending to below final excavation level. Shotcrete lagging was used to control erosion between king piles through the till.

Initially, a trial CSM program consisting of two CSM panels and two large diameter drill holes was implemented ahead of production to assist with finalizing the shoring design as well as developing the termination criteria of the CSM panels in the dense till. The constructed depth of the CSM panels was based on interpretation of real-time monitoring data. To assess and monitor the performance of the hybrid shoring system, inclinometer monitoring was carried out at five secant king pile locations. Further, pile target monitoring at the location of the secant king piles was also carried out to supplement the monitoring data.

The CSM technique for construction of the infill panels between secant piles was proposed because of the speed at which the shoring system could be installed in the variable fill, peat, wood debris and overburden, while meeting tight shoring performance requirements. Close collaboration within the design-build team enabled timely review of the subsurface conditions encountered during CSM panel and secant king pile construction, as well as monitoring performance of the hybrid shoring system during staged bulk excavation ensuring project-specific performance requirements are met.

This paper provides an overview of the design and construction aspects of the hybrid shoring system using the CSM technique, specifically the performance-based shoring design approach; the use of inclinometer and pile target monitoring data to assist with fine-tuning of the design; as well as construction challenges encountered during installation of CSM panels through the variable fill containing wood debris and man-made obstructions. This paper also discusses the results and value of anchor testing, and the merits of using real-time monitoring data as part of the engineering decision-making process for validating CSM panels constructed.

Influence of the Construction of Uncased Drilled Shafts at Close Proximity to MSE Wall Facing

Willie Liew and Matthew Doss, Tensar International Corporation

Mechanically Stabilized Earth (MSE) walls with geogrid reinforcement has grown in popularity since its first introduction in North Americas in the early 1980's due to its cost-effectiveness, performance and the long-term chemical durability of the reinforcement material. Geogrid reinforced MSE walls is now a common solution for supporting critical structures such as bridge abutments whether it is spread footing supported abutment or deep foundation supported abutment.

Deep foundation supported abutments are typically supported independently from the MSE structure by installing deep foundations that extend through the MSE structure and compressible foundation materials to competent bearing strata. The typical method used for bridge pile installation consists of extending temporary casings upward through the MSE structure as the walls are built thus allowing horizontal earth reinforcing elements to be located around the casings. Once the wall is complete, deep foundation elements are installed through the casings. This method is advantageous because the foundation is independent from the wall but is difficult to construct and adds cost to the project.

Recently, Tensar International Corporation and Retaining Walls Company developed and tested a new bridge piling installation method using high density polyethylene geogrid that allows for piling installation to proceed without the need for casings. In this new method, deep foundations consist of drilled shafts that are extended through the reinforced MSE wall backfill and installed in a one-step process after the completion of the wall. This paper describes the development of the method and construction observations used to determine the influence of the drilling technique on the stability of the geogrid reinforcement and the need for temporary casing on the stability of the MSE wall facing. This paper is of particular significance because it represents an important advancement in the construction of MSE walls for bridge abutments.

Trim Blasting Techniques – Best Practices and State of the Art

Sarah McAuley and Anders Frappell, TetraTech

One of the techniques used to remediate rock slopes is that of trim blasting. Trim blasting is often used in combination with scaling, rock bolting, the installation of rock fall netting, as well as other stabilization measures to control rock fall hazards and remediate slopes. Where an undesirable mass of rock exists that is too large, too fractured, too weak or too unstable to be rock bolted or supported by another method, trim blasting can be used. This also fits well into the hierarchy of hazard elimination. Trim blasting necessitates carefully controlled blasting techniques to ensure that the rock mass is removed without disturbing the remaining rock face behind the feature. This paper presents some of the key geological, and geotechnical characteristics of the rock that must be assessed when planning and carrying out a trim blast, as well as how the site characteristics affect the trim blast pattern, explosive requirements and contractual elements. The authors maintain that good trim blasting requires careful construction review throughout the drilling process and particularly during the loading and charging of the blast holes, so as to minimize disturbance of the rock mass. The paper also details some unusual trim blasts where the over air pressure, the vibration and fly rock needed to be controlled. These case studies on trim blasting are presented in detail.

Identifying Pre-existing Shear Surfaces and Slope Stabilization – A Case History Spanning Almost 30 Years

Mahmoud Mahmoud, GES Geotech Inc.

The Bear Creek Village (condominium development) in Grande Prairie, Alberta is located adjacent to the east crest of Bear Creek valley. The Bear Creek Village was constructed in three phases during 1997 to 1999. Previous geotechnical investigations and engineering assessments for the development were undertaken by several consulting firms in 1995, 1996, 1999 and 2000. The apparent problem was related to the location of top-of-bank line and building foundation setbacks from the slope crest running along the western half of the development site and assessment of the risk of slope instability and its potential impact on the safety of the residents at Bear Creek Village. However, the main problem was later identified to be something much more critical. Closer look and review of some of the boreholes that were drilled for previous studies, prior to 1995, showed evidence of slickensides within the clay deposits. From a review of old air photos, pre-1995 geotechnical reports it was identified that historical landslides have occurred in the general area of Bear Creek Village. Those reports had thus concluded that weak-strength shear zones in the lower depths should be taken into account in assessing any future developments. An extensive geotechnical borehole investigation program and CPT testing was initiated to confirm the extent of preexisting shear zones and/or failure surfaces. The investigation program confirmed the presence of pre-existing shear zones and failure surfaces, which were later incorporated into slope stability analysis that indicated instability was along a non-circular slip surface. Setback distances corresponding to factors of safety of 1.5 were in the range of 35 to 45 m beyond the crest as compared to the initial disagreement between respective consulting engineers, which were debating 5 m versus 10 m of setback. Based on the slope stability analyses a shear key system was designed to provide an effective increase in factors of safety for slope stability, thus significantly decreasing the required setbacks from the slope crest. Given that the condominium units had already been built on site, establishing 35 to 45 m setbacks due to presence of shear zones would have meant expropriation of homes; which was unacceptable to all parties including the homeowners. A shear key system was developed that enabled achieving factors of safety that were satisfactory to the City of Grande Prairie, as jurisdiction having authority for public safety.

Implementation of Open Pit Slope Design: Practice Reconciliation Techniques

Edward Saunders, SRK Consulting Ltd.

The implementation of an open pit slope design is a function of the mine operational capabilities and procedures, and the actual stability performance. Typically, the slope designs that are to be implemented are largely based on the results of drilling investigations and office-based stability assessment without the luxury of hundreds of metres of pit wall exposure to evaluate geotechnical properties such rock mass strength or numerical modelling puts. Further, an open pit may be significantly developed and the actual geotechnical conditions are significantly different to those expected during the design work, resulting in potentially new stability risks.

From a geotechnical perspective, the implementation is closely related to the reconciliation of the geology, structure, rock mass and hydrogeology components of the geotechnical model that form the basis for stability assessment and the open pit slope design parameters. This paper presents practical examples of reconciliation strategies used to verify existing slope design parameters and to support mine operations which can include the mitigation of existing instabilities, the prediction of future instability and the identification of optimization opportunities. The reconciliation strategies focus on the continual understanding of the geotechnical model, and the relationship between the geotechnical engineer and mine personnel. In addition, verification techniques are presented to demonstrate the expected geotechnical conditions against the actual conditions exhibited in the pit slopes.