Yukon Engineering Excellence Award Nomination

Project Name: Rock fall control and Mitigation at the Mayo A Powerhouse

Yukon Engineering Firms: Tetra Tech (NELPCo's Engineering Service Provider) & Yukon Energy

Yukon Engineering Professional Team: Tetra Tech – Richard Trimble P.Eng., Charles Hunt P.Eng., Chad Cowan P.Eng. (NELPCo – VP Operations), Ron Gee P.Eng. (Yukon Power).

Project Description:

Mayo 'A' Powerhouse is part of the 'Mayo Hydro Facilities' located approximately 5 km north of the town of Mayo, Yukon, Canada. The facility is owned and operated by Yukon Energy Corporation (YEC). The original powerhouse, commissioned in 1951, remains, and was constructed adjacent to a 70 m high heterogeneous rock and soil slope with minimal catchment between the slope and the powerhouse building.

During the spring of 2016, a series of rock fall events occurred, resulting in a number of near misses, and actual impacts to the roof and sidewall of the powerhouse. The damage caused, and the resulting repair work led to minor disruption to the plants operation, and highlighted the inadequacy of existing rock fall hazard mitigation measures existing up slope of the powerhouse. The site can generally be characterized by the following conditions;

- Critical infrastructure constructed at the base of a roughly 70 m high rock slope, with thick overburden soil slopes near the crest. It is believed the soil slopes are at or near their angle of repose.
- Rock consists of extremely weak to very weak laminated mudstone, interbedded with medium strong mudstone. As a result, differential erosion of the weaker layers has led to the development of overhanging rock masses. General rock mass erosion has led to the development of open joints at and behind the rock bluffs on the slope, while cyclical freeze thaw weathering acts to further weaken the rock mass. This band of mudstone bluffs is a major source of rock fall.
- Over steepened overburden soils, and removal / deterioration of slope vegetation, have resulted in progressive erosion at the crest. The erosion has caused sub-rounded granitic cobbles and boulders to fall out and deposit over the slope creating a rock fall hazard with the potential for high-energy rock fall events.
- Immediately above and behind the powerhouse on a break in the slope gradient rock fall from the bluffs and the soil slopes has deposited and accumulated.
- Catchment at the base of the slope is not effective, immediately behind the powerhouse building there is a gap of 1 to 2 m separating the building from the slope. Furthermore the transmission building is directly below the main band of overhanging rock bluffs.

During the site inspection a qualitative risk assessment was undertaken to identify sources of rock fall on the slope and assess the consequence of rock fall from that location on structures below. A high risk was defined as a location where large blocks of rock could fail and impact a structure, or where small blocks of rock could build up significant velocity and impact a structure.

Given the challenging access conditions, and the remote site location, a departure from the traditional scaling, and construction approach was required. Prior to further development of design concepts, the following requirements were defined:

- Rock fall must be limited to prevent further damage to existing infrastructure. This negated the use of traditional scaling and any trim blasting options.
- Safe working conditions must be maintained for the construction crew and powerhouse operators at all times. Minimize disturbance to ongoing operation of the power facility.
- Mitigation measures were required to address the high hazard locations, such measures should be easily maintained.
- Work should be completed as soon as reasonably possible, to avoid the onset of poorer weather conditions.

Tetra Tech Canada Inc.
61 Wasson Place
Whitehorse, YT Y1A 0H7 CANADA

A rock fall analysis was completed using RocScience software RocFall, on two sections of the rock slope, above the powerhouse, and above the new transmission building. The analysis was completed to determine the catch fence capacity required to arrest rock fall derived from the two key rock fall hazard sources.

In consideration of the above modelling and on site assessments, a 30 m long, 3 m high, 250 kJ rigid post catch fence was proposed, to be installed on a natural bench below the overhanging rock bluffs and extend towards the east to the boundary of where the medium risk zone starts. Due to site restrictions, we were unable to undertake direct scaling and trim blasting methods, and construction of permanent rock fall protection measures had to be undertaken beneath unstable, non-scaled rock and soil slopes. The proposed location of the catch fence required that work be undertaken beneath the high hazard, 4 to 5 m high overhanging dilated rock bluff, and downslope of a number of exposed overburden soil slopes. This presented two sources for rock fall during construction, namely, direct from the overhanging rock face, and clasts from within the overburden soil slope. To provide safe working conditions, a passive mesh system, anchored behind the crest of the exposed rock bluff, and raised 2 m was devised. The work was constructed within 2 months from the detailed site inspection and assessment prior to winter, the following key innovations and engineering excellence occurred:

- This is the design and installation of one of the first rock catch fences in the Yukon, constructing a 250 kJ, 30 m long x 3 m high, rock catch fence at the base of the overhanging bluffs on the western side of the cable tray. The intent of the catch fence is to intercept rock fall that may impact the powerhouse and transmission building.
- Use of a construction chute to remove accumulated talus and debris material from above the powerhouse. The purpose of the construction chute was to channel the material down the slope without impacting the powerhouse, to a suitable location for removal. A perhaps unique application of a scaling chute for scaling.
- Installation of draped mesh over the overhanging outcrops on the west side of the slope. The intent of this mesh was to allow for safe working and scaling of the overhanging bluffs where rock fall sources are present. Though the mesh was designed to provide temporary protection for workers, it will remain in place, and will continue to reduce the rate of slope unravelling, and provide worker protection in future slope maintenance programmes.
- All of the work was completed from the rock slope face, using a roped access specialist contractor where a crane or helicopter would traditionally be used. This helped to reduce construction costs. Construction work began on August 30, 2016 and was completed on September 20, 2016. A very short duration before winter.

Mitigating the hazard in such a spatially constrained and remote site, with critical infrastructure both at the base and on the slope, required a departure from the traditional scaling, remediation, and construction approach. Instead, a staged construction and hazard mitigation schedule was adopted, requiring a number of innovative techniques and solutions aimed at minimizing further damage, total project costs, and weather related delays.

The project was completed on budget, ahead of deteriorating winter conditions, and has provided much needed protection from rock fall events. Going forward, recommendations for additional slope remediation items were made to address the medium and lower risk items identified. General slope maintenance is also proposed to ensure that the system works efficiently.

This project was an important NELPCo Project for Tetra Tech. NELPCo is a limited partnership corporation owned by NND Development Corporation (NNDDC) and Tetra Tech, who's aim is to develop business and employment opportunities associated with providing Environmental and Engineering Services in the Traditional Territory of the Na-Cho Nyak Dun First Nation (NND).

A paper on the project was accepted and presented at the American Rock Mechanics Conference in 2017. The paper is entitled Case Study: Rock Slope Remediation at Mayo 'A' Powerhouse, Yukon, Canada (the Authors were Charles Hunt P.Eng.(YK), Ron Gee P.Eng. (YK), & Jack Price P.Eng. (BC))

Bio of Nominee (Engineering Lead):

Mr. Hunt is the Manager of the Rock Engineering group in Vancouver, BC. He has over 20 years of experience with respect to rock engineering, and specifically rock cut and slope design/remediation, rock tunneling and rock foundations (and grouting). He has been a member of the Association of Professional Engineers Yukon since 2012 and within BC since 2006. He has worked on a number of mining and civil engineering projects in the Yukon for both government and private clients. He has a Masters degree in Applied Geotechnics from Camborne School of Mines and international experience working in Hong Kong (4 years), Indonesia (2 years), and United Kingdom (4 years) and for the last 12 years in Canada.