AVALANCHE CONTROL ROPEWAYS
COQUIHALLA HIGHWAY AVALANCHE SAFETY PROGRAM

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ABSTRACT

Two avalanche control ropeways were constructed as part of the avalanche safety program for the Coquihalla Highway. The contract for the construction of these ropeways was designed to utilize the latest technology and to encourage research and development of avalanche control ropeway systems. The two ropeways are 4.3 kilometers and 6 kilometers in length. Both ropeways use diesel-hydraulic drive systems, controlled by computers located in the drive stations. The ropeway operator programs the drive computer with pre-determined target locations and then attaches from one to ten explosive carriers to the haul rope. The explosive carriers are radio controlled and operated from the drive stations. Explosive packages of from one to ten kilograms may be used. Once a carrier reaches its target location, the operator, via radio signals, positions the explosive charge at or above the snow surface and detonates the explosive.

The avalanche control ropeway systems are a safe and effective method of accurately delivering an explosive charge to a target. They have minimum manpower requirements and require very short road closure delays to conduct the explosive control work.

INTRODUCTION

The Coquihalla Highway is located between the communities of Kamloops and Hope, B.C. It is a main transportation artery between the interior population centers and the major coastal population centers of British Columbia. Winter traffic volumes in 1987/88 averaged 2300 vehicles daily with maximum volumes of 9000 daily. The avalanche safety program for the highway is required to keep road closure times for avalanche control to a minimum and provide an acceptable level of safety for the user.

The avalanche control requirements for this project dictated the need for methods of avalanche control that would deliver an explosive charge accurately to its target, during storm periods, day or night. Artillery was one option being considered, however, the difficulty of obtaining guns and ammunition and the uncertainty of continuous supply encouraged us to explore additional options.

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In the spring of 1985, a representative of the British Columbia Ministry of Transportation and Highways, Snow Avalanche Section, visited Europe to view existing avalanche control ropeway systems and determine if similar systems would meet the needs of the avalanche control program proposed for the new Coquihalla Highway. It was decided to construct two ropeways, one in the Cassio Miranda avalanche area, and one in the Great Bear avalanche area. The two ropeways operate in conjunction with an artillery control program used on other avalanche areas within the pass.

CONSTRUCTION

Line and tower locations for the ropeways were determined by B.C. Highways, Snow Avalanche Section personnel in the fall and winter of 1985/86. The Snow Avalanche Section has been collecting avalanche occurence information in the Coquihalla since 1975. This information, along with detailed study of the avalanche starting zones, was used to determine potential tower locations. To ensure the proposed tower locations were the safest and most effective available, the locations were marked and observed throughout the winter of 1985/86. A detailed survey of the final tower and line locations was done in March and April of 1986.

Contracts for the construction of the two ropeways and supply of the explosive carriers were tendered in May 1986. The contracts were structured to meet the requirements of the control program and deal with the difficult winter conditions potentially encountered in the Coquihalla Pass. Emphasis was placed on utilizing the latest available technology and encouraging research and development of the explosive carriers and computerized ropeway drive controls.

The contract for construction of the two ropeways was awarded to Murray Latta Machine Co. Ltd. of Vancouver, B.C. The contract for supply of the explosive carriers was awarded to Band Electronics of Surrey, B.C. (now known as SSK Digital Communication Systems Inc.).

The Great Bear ropeway is 4.3 kilometers long, incorporating thirteen towers. Four of the towers required brace legs and eleven have snow creep and glide protection. Eight heliports were constructed to provide access to tower locations.

The Cassio Miranda ropeway is 6.0 kilometers long, incorporating fifteen towers. Five of the towers required brace legs and ten have snow creep and glide protection. Six heliports were constructed to provide access to tower locations.

On site construction began in June 1986. Access to all construction uphill of the drive stations was difficult and required the use of helicopters. A total of one hundred and fourteen concrete structures for tower and brace leg footings, snow creep and glide protection and heliports were constructed uphill. The placement of towers, heliport platforms and the haul ropes was also done by helicopter.

Poor soil conditions were encountered at both drive station locations. It was necessary to drive piles for the foundations at the Cassio Miranda site and undergo a large excavation for foundations at the Great Bear site. Construction continued throughout the summer, fall, and early winter of 1986. The ropeways were operational in February 1987.

DRIVE CONTROL SYSTEMS

Both ropesways have diesel hydraulic drive systems controlled by a computer located in the drive station. The operator programs the drive computer with predetermined target locations, then attaches the explosive carriers to the haul rope. Up to ten explosive carriers can be attached to the haul rope at one time. During the loading operation the drive computer automatically advances the haul rope the correct spacing, then stops permitting the operator to attach the next explosive carrier. Once all the carriers are attached to the haul rope the computer automatically moves the carriers to their target locations.

The haul rope travels at a maximum speed of six meters per second and slows to approximately one meter per second each time a carrier passes a tower. The drive computer monitors the location of the carriers in respect to the towers and automatically decelerates and accelerates the ropeway each time a carrier passes a tower.

The explosive charges are detonated at their target locations and the carriers are returned to the drive station. At the drive station the carriers can be removed from the haul rope or another explosive package attached and transported to additional target locations. The ropeway is fully reversible and carriers can pass around the drive bullwheel. The operator can intervene in the automatic operation and manually control the movement of the carriers.

A screen is located above the computer panel. This screen has the ropeway line location indicated on a map of the avalanche area. The movement of the carriers on the line is indicated by a progression of lights signifying each carrier. The operator can monitor the movement of the carriers throughout the operation.

The drive computer program is designed to safeguard the ropeway system through a number of sensors and counting crosschecks. In the event of an abnormal situation, the computer shuts the system down, sounds an alarm and indicates an alarm code to direct the operator to the specific problem. The computer monitors engine oil pressure, engine temperature, hydraulic oil pressure and temperature, and counterweight movement. Counting crosschecks are done on carrier location in relation to tower or target locations and rope speed. The program will not accept a target designation at or within an unsafe distance from a tower location or drive station. This ensures an explosive charge is not mistakenly detonated in a location which could damage the ropeway.

The drive computer also contains a de-ice program. This program automatically starts and stops the ropeway at selected time intervals to prevent the system from icing up during periods of heavy icing. Each ropeway has its own diesel generator and is independent of any outside power requirements. Each ropeway has its own bulk fuel storage with sufficient fuel for an entire winters operation.

EXPLOSIVE CARRIERS

The explosive carriers utilize a gel cell battery power supply, an electric winch, a radio system and a small computer. They are operated from a consul in the drive station. The carrier has the capacity to use an explosive package from one to ten kilograms. When the carrier is at its target location the operator communicates with it to conduct the explosive operation. Each carrier has its own address and is communicated with separately. Each step in the explosive operation requires a separate communication. Each communication is displayed on the control consul and printed on a printer attached to the consul. Through a series of communications, the operator lowers the explosive package to the snow surface, then raises it a selected distance above the surface. The carrier has a counter on the winch cable and monitors the distance between the explosive package and the carrier. This distance is transmitted to the operator when the explosive contacts the surface. The distance between the carrier and the explosive can be checked by the operator at any time. When the explosive package is in position the operator signals the detonation of the explosives. The explosives are detonated by an electrically initiated safety fuse assembly. When the explosives have detonated the carrier will communicate this to the operator and the operator can signal the rewind of the winch cable. The carrier is now ready for return to the drive station.

If the operator does not wish to lower the explosive to the actual surface, the explosives can be lowered any selected distance and detonated. This function is used if the operator is concerned with the explosive becoming snagged on surface debris or if the surface is extremely steep.

Should the explosive fail to detonate, the carrier will indicate this to the operator. Through the use of a misfire procedure the operator can raise the package and move the carrier to a safe misfire location. The explosive will then be lowered to the surface and managed similar to a handcharge dud.

The carrier has a number of safety features designed to protect the user and the carrier. Safety features include: An external disarm switch used during the loading operation. A timer disarm mechanism which ensures the carrier cannot be armed until it is a safe distance from the loading platform. The four radio commands leading up to the initiation of the safety fuse must be received by the carrier in sequence. The carrier will not arm if the explosive package is less than one meter from the carrier.

COST EFFECTIVENESS

Installation costs for the two ropeway systems were substantial. A number of factors contributed to these costs. Weather and snowfall data from the Coquihalla Pass indicated the potential for deep coastal snowpacks and severe icing conditions. This information dictated the need for relatively high snow load, snow creep and glide, and blue ice design forces. The length of the ropeways and the terrain they cover resulted in towers located in areas where access was difficult. The helicopter landing pads were constructed to manage the access problems. Poor soil conditions at both drive station locations resulted in significant extra costs. Research and development costs were necessary to make the Coquihalla systems safe and effective.

Installation costs for a similar system in a diferent location could be significantly different due to the many variables affecting supply and installation that are site specific.

The Coquihalla avalanche control ropeway systems have been in operation for two winters. Avalanche control ropeway systems of this size and level of technology are not only new to North America but relatively new to the world. Their final cost verses effectiveness can only be determined over a number of years of operation. The information and experience we have to date indicates these systems will be cost-effective and provide the level of service required for the Coquihalla Highway.

CONCLUSION

The Coquihalla avalanche control ropeway systems are a safe and effective method of avalanche control using explosives. They deliver an explosive charge accurately to its target. They can operate day or night in almost any weather conditions. They can be operated by a single person (a two person crew is used if available) and can use an inexpensive explosive package.

Research and development which took place during the Coquihalla project has resulted in a number of improvements to these systems. Experience gained during their installation and initial years of operation has resulted in a better understanding of their capacity and limitations.

When evaluating your present avalanche control program, or designing a program for a new project, avalanche control ropeway systems should be considered as a potentially attractive avalanche control option.