# STEEP SLOPES

***Surerus Murphy has exceptional knowledge in steep slope construction.***

Our steep slope construction is world-class because we follow proven methods in planning, design, implementation, winching and installation, and are quick to use innovative approaches to solving technical issues. By optimizing our experience in steep slope construction, we pass safety and efficiency benefits on to our clients.

***Surerus Murphy has specialized equipment, experienced engineers, and the latest technology to offer safe, efficient, and high-quality steep slope construction.***

Western Canada's mountain ranges are full of steep slopes that require specialized knowledge to safely navigate equipment and pipe along difficult angles and terrain, often in rural locations and in inclement weather conditions.

**Innovation helps us work safely.**

Much of our equipment has 3D GPS machine control that enables it to work independently on the slope. A CAD design is programmed directly into the machine so the operators can see the excavation's bounds, how deep they are required to go, and the locations of bell holes, ditch plugs, bends, and any contour changes should it be required. This innovation reduces the need for surveyors to be on the steep slope, improving productivity and efficiency as well as overall safety for the workforce.

**Design considerations always start with safety.**

Surerus Murphy's design process goes through many iterations with considerations from multiple departments to ensure hazards are identified and mitigated. Early in the design process, our construction managers and engineers walk the line to visualize the space and assess the slope's constructability. Unmanned Aerial Vehicles (UAVs) take pictures and get a change of perspective of the slope that would not normally be possible on foot or by a Utility Task Vehicle (UTV). The drafters use this information to develop a preliminary sketch of the slope for review with the construction team. With collaboration, the design is continually refined until it is ready for construction. The design continues to be reviewed and improved during construction as per the conditions experienced on-site.

**Surerus Murphy's innovative development of its steep slope winch program sets an industry-leading standard.**

Surerus Murphy has conducted proprietary testing on the effects of lifting on equipment stability at various angles to better understand the risks and modes of failures of equipment when its operating on steep slopes. This has informed and evolved the steep slope construction program, including improving the detailed drawings of all winch configurations authenticated by a Professional Engineer.

**Above all else, the most important aspect of steep slope construction is the proper use of winches.**


Dozer-Mounted HCH-100

## *HYDRAULIC WINCHES*

### Dozer-Mounted HCH-100

The HCH-100 is a hydraulically powered manual winch mounted on the rear of the dozer with the cable pointing out the rear. This winch requires an operator in the cab to control the winch for the equipment operating on the steep slope. Radio communication is set up between the winch operator and the down slope equipment operator. When winching is required, they communicate to move in tandem to maintain constant tension and execute movement on the slope safely.

***Specifications:***

- High-capacity winch that can carry 420 m of 1-1/4-inches wire rope
- Working Load Limit (WLL) of ~23,000 kg for the 1-1/4-inches wire rope
- Able to change the wire rope size on the spool to accommodate a greater length of smaller diameter wire
- Versatile winch that does not require installation of a control system for the equipment operating on the slope
- Typically used to winch excavators, dozers, muletrax, rock trucks, etc.

### Remote Operated Bulldozer (ROB)

The ROB dozer contains a hydraulically powered, remotely operated winch with two large spool drums on the rear of the dozer with the cables running over each track and up over the blade. The ROB has a radio control module that communicates with a radio control module in the equipment operating on the steep slope. This allows the operator on the slope to winch up and down the slope from inside their equipment, removing the need for an operator in the ROB. To winch up and down the slope, the operator must press the winch-in or winch-out button and adjust settings in the cab to ensure the equipment travel speed matches the speed of the winch.

ROB operators undergo a rigorous in-house training program where they are taught the controls and best operating practices.

ROB 850

ROB 950

***Safety features include a winch anchor sensor, spool sensors, and over tension sensors:***

- The winch anchor sensor is engaged if the winch were to move while in operation. When the winch is set in place, an anchor is driven into the ground, or a heavy weight is placed over it. A clip on a spring lanyard is attached from the anchor to a sensor on the rear of the ROB. Should the winch move, it will pull this clip out of the sensor and shut down all winch controls until the movement can be identified, corrected, and reset.
- The spool sensors are engaged if the wire rope comes off the drum and falls between the inside edge of the drum and the cab. A lever at the bottom of the drum is actuated by the wire rope and immobilizes the winch. The drum must be inspected, any deficiencies fixed, and reset before the winch can operate again.
- The over tension sensor engages when the tension on the wire rope exceeds a set amount (typically the WLL of the wire rope). This is calculated by the load sensor installed on the blade of the dozer. The wire ropes are fed through this load monitor before being attached to the down slope machine. As the equipment is working on the slope, they keep an eye on their display in the cab to monitor the tensions on the rope. If they exceed the allotted maximum tension, it will display the warning and pay out a small amount to relieve some of the tension to below the set amount.

***Specifications:***

**ROB 850**

- Each of the large spools mounted to the rear of the dozer is cable of holding 500 m of 7/8-inches wire rope
- WLL of each 7/8-inches cable is ~10,500 kg resulting in a combined capacity of ~21,000 kg
- Typically used to winch excavators, dozers, muletrax, 30T rock trucks, etc.
- Used in all construction phases except for pipe installation

**ROB 950**

- Each of the large spools mounted to the rear of the dozer is cable of holding 500 m of 1-1/8-inches wire rope
- WLL of each 1-1/8-inches cable is ~17,500 kg resulting in a combined capacity of ~35,000 kg
- Typically used to winch excavators, dozers, muletrax, 30T rock trucks, etc
- Used in all construction phases but not typically for pipe installation


Excavator mounted Timber Max

## Excavator Mounted Timber Max

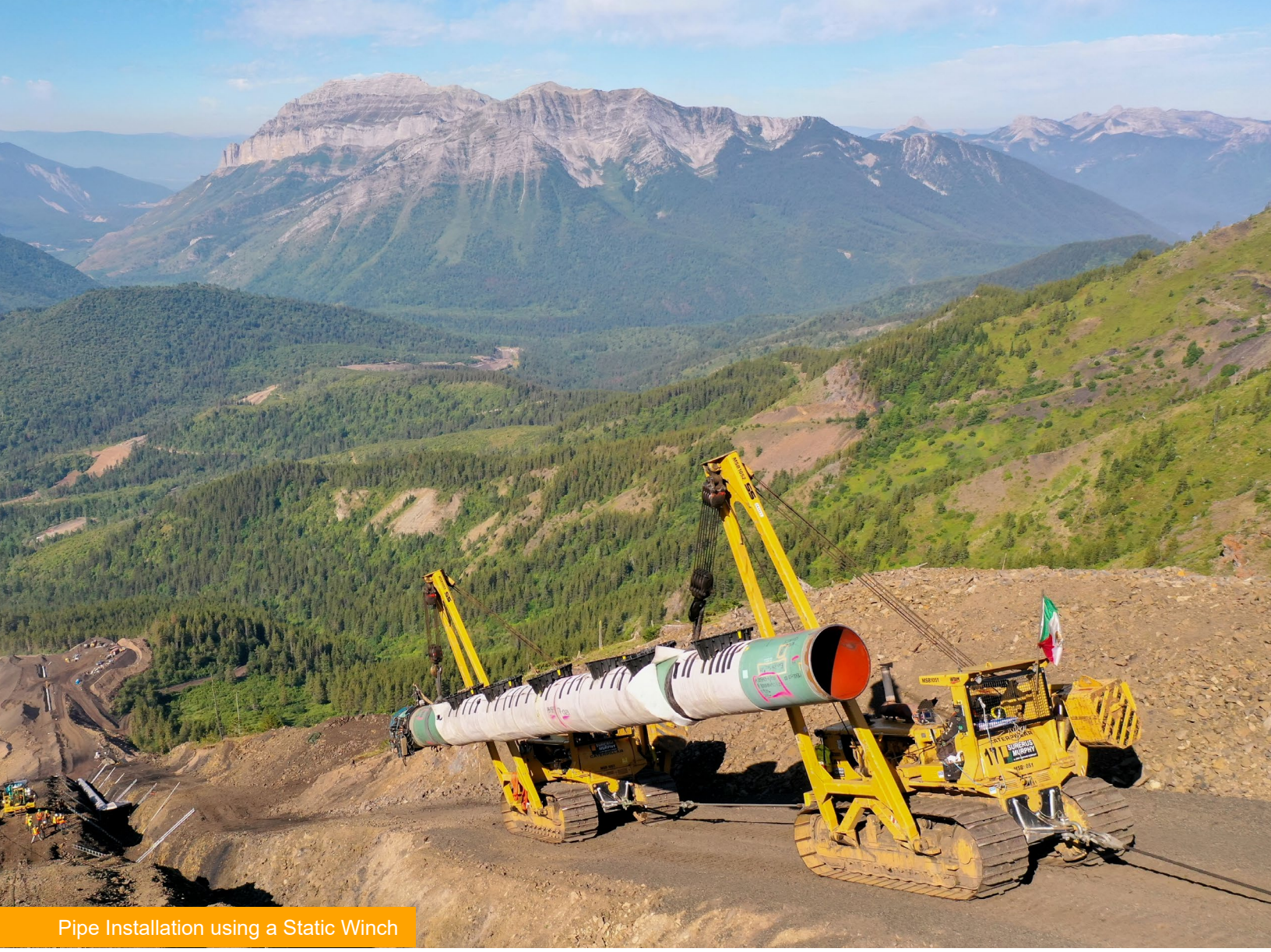
The Timber Max is a radio-controlled, remotely operated, hydraulically powered excavator mounted single-spool winch attachment. Excavators with the mounted winch attachment are outfitted with a control system that enables communication between the winch attachment and the down slope equipment. The down slope equipment is also outfitted with a control system display that is easy to change between pieces of equipment.

The Timber Max features an auto-tethering system that maintains constant tension to the down slope equipment. As the operator travels down slope, it reduces the tension on the winch cable by a user set amount and winches out. When the operator travels up slope, it increases the tension on the winch cable by a user set amount and winches in. As the operator is doing work and not moving on the slope, the winch holds the machine with a preset amount of tension. These settings are easily changeable on the display within the cab of the down slope equipment.

The display also has other information such as a video display of the winch to ensure the cable is spooling properly, an area to display errors should they come up, signal strength to the winch, and a night switch to lower the screen brightness during night operations.

***Specifications:***

- The large spool can hold 420 m of 1-inches wire rope
- WLL of the 1-inches cable is ~ 17,000 kg
- Typically used to winch excavators, dozers, muletrax, drill rigs, 30T rock truck etc.
- Used in all construction phases except pipe installation



Pipe Installation using a Static Winch

## *STATIC WINCHES*

### Design process

Static winches are used for pipe installation to ensure the slope installation is completed safely with equipment that can handle the task. Prior to selecting a static winch, a design will be developed detailing the post grade angle, length, and general profile of the designed slope.

The design will consider the installation requirements including space for the anchor, the winch, and for the side booms to stage flat at the top of the slope. In some cases where available space is tight there may need to be additional design considerations on the grade plan to create the required space.

### Field checks

Once the design is finalized and the slope has been graded/trenched, it is time to set up the winch. The static winch requires an anchor to be installed to secure the winch in place while it is winching equipment up and down the slope. This anchor is a design authenticated by a Professional Engineer that includes installation instructions, such as the depth to be buried, compaction requirements, geotechnical requirements, and testing. Once the anchor is installed it is pull tested to the safe working load limit described in the engineered drawings. The deflection is measured to ensure it is within the acceptable limits and the anchor is secured in compacted soil.


Electric Static Winch

### Electric Static Winch

This is the most commonly used winch in Surerus Murphy's fleet of equipment.

The Electric Static Winch can accommodate several different diameters and lengths of wire rope. However, Surerus Murphy often uses a 1-5/8-inches in diameter wire rope with approximately 350 m of cable on the drum. The Electric Static Winch can pull approximately 90 tonnes of tension on the wire rope but is limited to the working load limit of the cable that is approximately 43 tonnes. The wire rope has a line rider fitted on it in front of the winch that reads the tension in the cable to ensure that the winch operator does not exceed the working load limit of the cable.

The Electric Static Winch comes as two separate units that are required to operate, the generator, and the winch skid. The winch skid includes the electronic controls assembly, dual electric motors, gearbox assembly, and skid mounted remote operator station.

The Electric Static Winch requires careful coordination between the winch operator and the down slope equipment operator to ensure both parties are working in tandem.


Hydraulic Static Winch

## Hydraulic Static Winch

The Hydraulic Static Winch can accommodate several different diameters and lengths of wire rope. Surerus Murphy has used the Hydraulic Static Winch with cable up to 1-3/4-inches in diameter with up to 1 km of cable for an extremely long slope. The Hydraulic Static Winch can pull approximately 90 tonnes of tension on the wire rope but is limited to the working load limit of the cable that is approximately 70 tonnes. The wire rope has a line rider fitted on it in front of the winch that reads the tension in the cable to ensure that the winch operator does not exceed the working load limit of the cable.

The Hydraulic Static Winch requires three separate units to operate - the generator, the Hydraulic Power Unit (HPU), and the hydraulic winch. It is also outfitted with a spooling gear system that is chain driven off the winch shaft to guide the wire rope properly onto the winch as it pays in and out.

The Hydraulic Static Winch provides constant tension by using the working fluid to either generate power to assist equipment walking up a slope or provide a braking force to support equipment walking down a slope.

Unmanned Aerial Vehicle (UAV)

GIS & Civil 3D

**Unmanned Aerial Vehicles (UAV) and 3D imagery provide real-time data that we use on steep slope construction to ensure engineering is optimized and hazards are mitigated to protect the workforce who is overseeing construction in these environments.**

## Unmanned Aerial Vehicle (UAV)

Steep slopes are by nature hard to reach, often in remote and inaccessible areas. Surerus Murphy has a fleet of precision UAV's that are flown to enable quick and accurate data collection on volumes of grade material moved, pipe installed, as-built slope angles, and training tools for steep slope operators to review performance leading to improvement. This data is shared for an accurate, manipulatable 3D visual of design concepts, progress, videos, pictures, and other key information that would not otherwise be available at the ground level. These models are also used to track and record construction progress and determine areas that maintenance needs to be performed, providing lessons learned for future improvements. Importantly, they also improve safety by providing instant feedback to operators and crews involved in a winching operation.

Using UAVs reduces the physical workload and improves safety for our surveyors on the ground by not requiring them to climb these potentially dangerous slopes. The use of UAV's has become a key part of Surerus Murphy's workflow from design to construction to project close out.

## GIS & Civil 3D

Slope analysis – available workspace, length and angle of slope, and geotechnical conditions – are all required before the correct winch for the job is selected. If there is no LIDAR data available from the client, our drafters will create a 3D sitemap using data collected from one of our in-house drones. The construction management team will also physically walk the site to get a firsthand visual of the work scope. From this information, a preliminary drawing is created and presented to the construction management team for collaboration and review. The design process is iterative and will go through several revisions before a construction design is selected.

With the information collected, a 3D model of the steep slope is created with an animated timeline that outlines the flow of construction. This tool is great for key stakeholders to understand the construction process and to drive collaboration.

Throughout the course of construction, cut and fills are analyzed in regular intervals from UAV data collected to ensure design boundaries are maintained and expected production rates and estimates for cuts/fills are met.

3D Sitemap of Flathead Ridge

# Stories from the Field

## CASE STUDY – FLATHEAD RIDGE

***Surerus Murphy installed ~32 km of 48-inch pipe on TC Energy's Elko natural gas pipeline system that transports product from near Fernie, B.C. to the US border where it services their clients.***

***As part of our construction, we were challenged with installing pipe on a steep slope called Flathead Ridge that many believed could only be completed with a cable crane system. Surerus Murphy's construction managers, engineers, and design experts evaluated the slope and determined conventional winch construction was possible.***

***The decision to use conventional winches was made only after considerable analysis at a desktop exercise level that considered access, pre-grade angles and geotechnical observations. When we were confident in our plans, we presented a preliminary construction design to the client that visually depicted the expected right-of-way design and available space for winch setup.***

***To guide schedule and progress, the 1-km long Flathead Ridge was split into seven consecutive sub-slopes in which the construction design on each sub slope was further refined to detail winch selection, locations, and spatial requirements. Additionally, grade design was refined and finalized to show post-grade slope angles, ensuring sufficient right-of-way width for pipe installation equipment as well as the removal of grade material volumes, including storage locations for excavated grade.***

***The pipe installation execution was also modelled, discussed, and finalized to include spatial requirements for pipe storage, above-ground pipe welding, and acceptable joint section sizing for each weld that was to take place on the slope. Combined, this information informed a schedule that was presented to the client and formalized.***

***Before grading, the finalized design was created into a 3D machine control file and uploaded into all the 3D grade-controlled excavators. Each sub-slope was excavated to the exact shape of the designed right-of-way. Our UAV operators sent the construction data from the sub-slopes to the CAD technologists for analysis, ensuring the slope was being excavated as designed, storage volumes were as expected, and production rates were being met.***

Access road near the top of Flathead Ridge

Pipe Installation

***The ditch design was created using the as built pipe dimensions. All measurements and bend locations are designed in Civil 3D to ensure precision placement to the highest accuracy as per the construction execution requirements. Each pipe was labelled with its exact position on the pipe installation drawing and required bend angle to ensure seamless installation which minimizes time and rework while on the dangerous slope.***

***Professional engineers reviewed and approved drawings whereby an easy-to-use hydraulic static winch – chosen for this application for its ability to withstand constant tension, increased pull capacity and increased drum size that allowed for longer, robust cable – was installed at the top of the slope, pull tested to ensure the anchor was installed in competent ground and did not exceed deflection specifications under load. This selection of winch is what made this long slope installation feasible.***

***A sideboom equipped with proprietary load monitoring equipment was attached to the hydraulic static winch. The load monitoring equipment enabled the sideboom operator and nearby foreperson spotting the operation to see how much tension the sideboom was applying to the wire rope. The foreperson and sideboom operator-maintained communication with the winch operator to ensure the tensions was within the working load limits and that descent/ascent on the slope was within expected travel speeds.***

***A result of the proactive approach Surerus Murphy takes to pre-planning, design, implementation, innovation, inspections, and maintenance. The field personnel and equipment performed exactly as expected with little to no downtime.***

**Surerus Murphy diligently plans its steep slope execution and uses its expertise and resources in a way that makes its steep slope executions a point of differentiation.**

Strong relationships with winch designers, manufacturers, and operators; proprietary load monitoring technology, use of technology and innovation, collaboration with engineers, designers, and clients; and, backed by our commitment to safe operations, puts Surerus Murphy as an industry leader in steep slope construction.

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