Members: Managing Edge Friction

Richard Delaney November 22, 2014 Member content, Test Reports 1 Comment

There are many improvised and proprietary options for both protecting ropes and managing friction over edges.

Rope access technicians have opted historically for simple, light weight solutions that provide protection for:

- limited rope movement during edge transitions,
- vertical movement associated with rope stretch during maneuvers, and
- unexpected lateral movement during work

Rescue technicians establish systems for lowering and raising and thus are more likely to choose heavier solutions that:

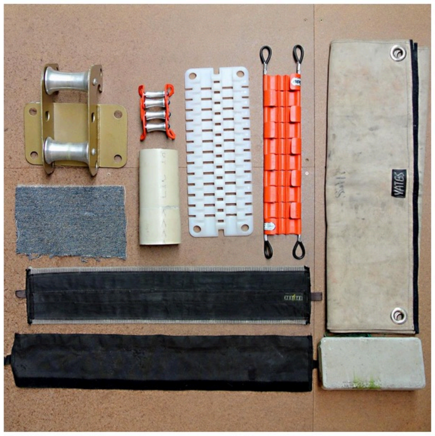
- minimise friction,
- consider the heat produced at high friction interfaces, and
- add height to ease management of a load over an edge.

Thus a key consideration in selection is whether there is intention to haul or lower a loaded rope.

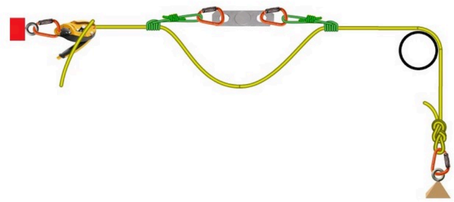
We are now seeing a greater awareness on rope access job-sites of the importance of pre-rigging for rescue. This raising or lowering of an injured workmate can be safer and faster than more traditional contact rescues. Pre-rigging for rescue must involve a consideration of friction.

Tests

During November 2014, a range of common edge management options were placed on a 90° edge and assessed for their relative efficiency while raising and lowering 75kg and 100kg load using Edelrid SuperStatic 11mm nylon rope.



A tension load cell was placed on the rope between the edge and the raising/lowering device to measure the tension associated with each movement. Raising was done with a Skyhook Rescue Systems winch driven at low speed to avoid bounce. Lowering was also performed using the winch in capstan lowering mode. It should be noted that the recorded value was a visual average of the load cell plotted graph and taken while the load was moving through at least 1m. There was a slight observable difference in the threshold to initiate movement (static as opposed to kinetic friction) but this value was not recorded.



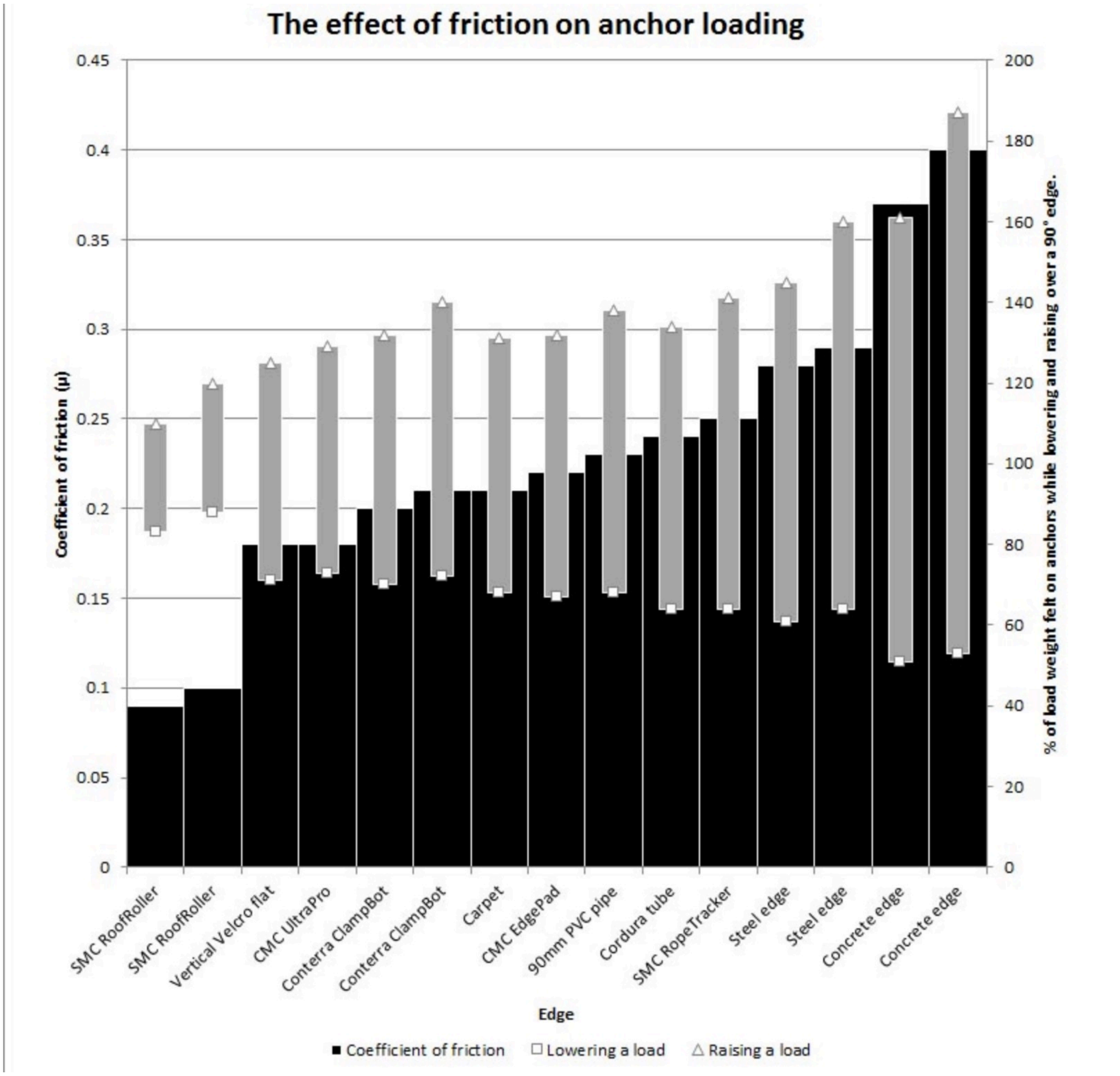
Recording both the raising and lowering tension allows the calculation of a coefficient of friction without knowing the exact mass of the load. This is done using by eliminating the weight (W) from the versions of the Capstan equation for each operation to give:

$$\mu = \frac{\ln\left(\frac{T_{raise}}{T_{lower}}\right)}{2\varphi}$$

Given that the edge angle (ϕ) is 90° we can now determine the coefficient of friction (μ) for each scenario. Low values of μ should indicate low friction and a less noticeable difference between the tension required for raise and lower.

Results

Edge	Mass (kg)	Raise (kgf)	%Raise	Lower (kgf)	%Lower	μ	Observations
SMC RoofRoller	100	110	1.10	83	0.83	0.09	
SMC RoofRoller	75	90	1.20	66	0.88	0.10	
Vertical Velcro flat	100	125	1.25	71	0.71	0.18	Fabric melting
CMC UltraPro	100	129	1.29	73	0.73	0.18	
Conterra ClampBot	100	132	1.32	70	0.70	0.20	
Conterra ClampBot	75	105	1.40	54	0.72	0.21	
Carpet	100	131	1.31	68	0.68	0.21	Carpet melting
CMC EdgePad	100	132	1.32	67	0.67	0.22	Canvas minor marking
90mm PVC pipe	100	138	1.38	68	0.68	0.23	PVC melting
Cordura tube	100	134	1.34	64	0.64	0.24	Cordura melting
SMC RopeTracker	100	141	1.41	64	0.64	0.25	
Steel edge	100	145	1.45	61	0.61	0.28	
Steel edge	75	120	1.60	48	0.64	0.29	
Concrete edge	100	161	1.61	51	0.51	0.37	Rope sheath fluffing
Concrete edge	75	140	1.87	40	0.53	0.40	Rope sheath fluffing

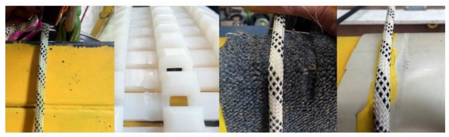

The effect of friction on anchor loading
Coefficient of friction (µ)
% of load weight felt on anchors while lowering and raising over a 90° edge.
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0
20
40
60
80
100
120
140
160
180
200
SMC RoofRoller
SMC RoofRoller
Vertical Velcro flat
CMC UltraPro
Conterra ClampBot
Conterra ClampBot
Carpet
CMC EdgePad
90mm PVC pipe
Cordura tube
SMC RopeTracker
Steel edge
Steel edge
Concrete edge
Concrete edge
Edge
Coefficient of friction
Lowering a load
Raising a load

Observations

These tests show that many common rope/edge protection options will hinder hauling operations and result in equipment damage. The values for hauling over unprotected steel can be used to consider hauling through 90° redirect carabiners as the results will be similar.

The results seem reasonable and clearly show that spinning rollers provide the lowest friction edge interface. The Russ Anderson/SMC Roof Roller has bearings and thus is more efficient than the bushed Conterra ClampBot.

Even though the load was only moved through one vertical metre, most of the other options resulted in either damage to the rope or the edge protector. All of the synthetic protectors would have melted right through if the load was moved through a significant distance. The tension varied noticeably with synthetic options and as they melted, it is assumed that this melting resulted in some lubrication of the interface. This melting also resulted in deposition on, and glazing of the rope sheath.



While the extra 50% effort required to haul can be problematic, the reduction by 50% during lowering can reduce the hit on equipment and anchors. Thus, when lowering, introducing a high friction interface such as a carabiner, may be desirable.