



Industrial rope access - Investigation into items of personal protective equipment

Prepared by
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for the Health and Safety Executive

**CONTRACT RESEARCH REPORT
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9 PRUSIK KNOTS

9.1 INTRODUCTION

Prusik knots are tied around the working rope using a supple rope, or cord, whose diameter is, preferably, smaller than that of the working rope. They are designed to grip the working rope when loaded, but slide when unloaded.

They are widely used by both rescue teams and arboriculturalists, particularly in the United States of America. Within rope access they are not widely used and as a result there is little consensus on which knot should be used for what purpose. This is partly due to the variety of suitable knots and partly due to the variations in performance due to rope types. Just as there is no standard working rope, there is no standard rope for tying prusik knots. The resulting permutations possible from these variables mean that it is very difficult to predict how a knot will perform. Most users have to gain this knowledge from experience. The following tests simply serve to illustrate how, under static loads, different knots behave on different ropes.

The different types of knots have slightly different properties, and hence different knots are preferred in different situations. Similarly different ropes tend to be preferred for different knots. The five knots tested were those used by respondents to the questionnaire.

9.2 TESTS

Five different knots were tested, using three diameters of working rope and two types of prusik rope. In addition, one of the working ropes was obtained and tested in both a new and a worn state. Most prusik knots are tied with a closed sling of rope (prusik loop) rather than a rope end. The Blake knot is the only exception to this.

Kernmantel and hawser laid suspension ropes were tested. Polyamide from Edelrid and polyester from Beal for the kernmantel ropes. The hawser laid rope was made from polyamide. The material used for the knots was 10 mm diameter "Prusik Regate", made from polyester and 6 mm accessory cord, both made by Beal.

The knots were subjected to a static test to determine the force that they would hold without slipping. The test was limited to 4 kN: knots which reached this force without slippage then had to hold it for 2 minutes to detect creeping.

The results can only be taken as a guide, however, as many factors can affect their performance.

The age and state of both the working rope and the prusik rope are very important: brand new rope may not grip as well as older rope that has been worn in and lost some of its sheen.

Slight differences in tying and 'setting' the knot will affect how readily the knot grips the rope when first and subsequently loaded. Similarly varying the diameters of both working rope and prusik rope will affect performance.

9.3 BACHMANN KNOT



Figure 55
Bachman knot tied with 6 mm accessory cord

This knot is different from the others in that it is tied around the back bar of a karabiner as well as the rope. In the tests an offset 'D' 12 mm steel industrial karabiner was used. The karabiner is not used as a handle and will cause the knot to slip if it is weighted. The knot's advantage is that it does not jam and extra friction can be easily added.

It held the 4 kN force on all the ropes when tied with 6 mm accessory cord.

When tied with 10 mm Prusik Regate rope on kernmantel ropes it slipped on 10.5 mm, between 0.6 kN and 1.0 kN, and on 13.5 mm, between 1.6 kN and 1.9 kN, but held the 4 kN force on the hawser-laid 12 mm rope.

9.4 BLAKE KNOT



Figure 56
Blake knot tied with “Prusik Regate” 10.0 mm rope

The Blake knot is the preferred knot amongst arboriculturists. In contrast with the other knots it is tied with a rope end rather than a loop.

It was the only knot tested to hold the 4 kN force for all test combinations. With the thicker 10 mm Prusik Regate rope it released easily. When tied in the thinner 6 mm accessory cord it was a little more difficult to release.

9.5 FRENCH PRUSIK



Figure 57
French prusik knot tied with 6 mm accessory cord

The French prusik is one of the simplest prusik knots, its main advantage being that it will release under load.

In all the tests it was very easy to release after the load was removed. It was able to hold higher forces when used on the thicker 12 mm and 13 mm ropes. On the 10.5 mm rope it slipped at 0.5 kN when using 10 mm Prusik Regate rope and at 1.3 kN on the thinner 6 mm accessory cord.

9.6 KLEIMHEIST KNOT



Figure 58
Kleimheist knot tied with 6 mm accessory cord

Popular in climbing circles, the Kleimheist is another fairly simple knot. The knot was tied using a sling made of 6 mm accessory cord. This was wrapped around the rope two or three times and then back through itself, to create a type of helical knot.

When tied in the thicker 10 mm Prusik Regate rope it slipped on all the ropes at forces below 0.5 kN. In contrast, when tied with 6 mm accessory cord it held the 4 kN force on all the ropes.

9.7 PRUSIK KNOT



Figure 59
Prusik knot tied with 6 mm accessory cord

The prusik knot is the original, and best known, 'ascender' knot. It is based on a Lark's foot but with extra turns.

It held the force on all but one test. Tied with the 10 mm Prusik Regate rope the knot slipped at 0.5 kN when tested on the 10.5 mm rope.

9.8 SUMMARY

Prusik knots clearly work. Some are better suited to holding large loads while others are more suitable when an easy release is required.

The combination of main rope and prusik rope is critical to how the knot will behave. Even with the limited variety tested, significant differences are seen between the combinations. Great experience would be required to predict the behaviour of any combination. It would be more realistic to adopt one knot and rope combination, and experience its behaviour until its performance in different situations can be assured.

For most situations, in rope access, a device would be available which would perform in a predictable fashion. Prusik knots are probably best suited to non-PPE applications such as hauling and suspending equipment.

There is much scope for further work on prusik knots. A study into their behaviour under dynamic loads would be particularly interesting, as concerns are often raised about melting, due to friction, when the knot slides under heavy loading.

12.18 APPENDIX 18 PRUSIK KNOTS

**Table 35
Prusik knot tests**

Bachman knot							
Main rope			Prusik cord (mm)	Pass/ fail	Sliding force (kN)	Comments/ ease of release	
Brand	type	Ø (mm)					
Edelrid	Low stretch	10.5	Prusik Regate 10	Fail	0.6-1	Steady slip	
Beal Baobab		13.5		Fail	1.6-1.9	Steady slip. Easy to release	
Hawser new	12			Pass	N/A.	Little slippage. Easy release	
Hawser used				-	-	-	
Edelrid	Low stretch	10.5	Accessory cord 6	Pass	N/A.	Slight slippage whilst loading. Very easy to release.	
Beal Baobab		13.5		Pass	N/A.		
Hawser new		12			Pass		N/A.
Hawser used					Pass		N/A.
Kleinheist knot							
Edelrid	Low stretch	10.5	Prusik Regate 10.	Fail	0.3-0.4	Slipped steadily at low loads	
Beal Baobab		13.5		Fail	-	At 4 kN, knot inverts, twisting rope and reducing function.	
Hawser new		12			Fail	0.4	At 4 kN, knot inverts as above. Very difficult to release.
Hawser used					Fail	-	Knot inverts at 2.8 kN. Very difficult to release.
Edelrid	Low stretch	10.5	Accessory cord 6	Pass	Jerky slippage 2-4	Release OK	
Beal Baobab		13.5		Pass			
Hawser new		12			Pass	No slippage	Release OK
Hawser used					Pass		

Note: 'Pass/Fail' in the above table only applies in relation to the test and criteria employed, and may not be relevant to the safety and practicality of the item in question when it is used in any specific application

Table continued on next page

Prusik knot						
Main rope			Prusik cord (mm)	Pass/ fail	Sliding force (kN)	Comments/ ease of release
Brand	type	Ø (mm)				
Edelrid	Low stretch	10.5	Prusik Regate 10.5	Fail	0.45	Releases easily. Slipped at relatively low loads
Beal Baobab		13.5		Pass	3.8 slight slippage	Stretches Baobab sheath releases easily
Hawser new	12	Accessory cord 6		Pass	2.8	Slipped during increasing force, holds static load. Release difficult
Hawser used				Pass	3.5	Slipped slightly. Difficult to release.
Edelrid	Low stretch		10.5	Pass	Little slippage	OK release
Beal Baobab			13.5	Pass	Little slippage	OK release
Hawser new	12	Accessory cord 6	Pass	No slippage	Easy release	
Hawser used			Pass	No slippage	Easy release	

Note: 'Pass/Fail' in the above table only applies in relation to the test and criteria employed, and may not be relevant to the safety and practicality of the item in question when it is used in any specific application

Table continued on next page

French prusik						
Main rope			Prusik cord (mm)	Pass/fail	Sliding force (kN)	Comments/ ease of release
Brand	type	Ø (mm)				
Edelrid	Low stretch	10.5	Prusik Regate 10.5	Fail	0.4-0.55	Slides steadily at low loads. Releases very easily
Beal Baobab		13.5		Pass	3-3.4 starts to slip jerkily	Releases very easily
Hawser new		12		Fail	2.5 jerky slippage	Reaches 3.5 kN during jerk. Very easy to release
Hawser used				Pass	Slight slippage as it beds in	Releases easily
Edelrid	Low stretch	10.5	Accessory cord 6	Fail	1.3	Slipped steadily at first, then jerkily Very easy to release
Beal Baobab		13.5		Fail	3	Slipped steadily at 3 kN. Very easy to release
Hawser new		12		Pass	~40 mm slippage	Very easy to release
Hawser used				Pass	~30 mm slippage	Very easy to release
Blake knot						
Edelrid	Low stretch	10.5	Prusik Regate 10.5	Pass	Slight jerks at 3.6	Easy release
Beal Baobab		13.5		Pass	Little slippage	Releases easily
Hawser new		12		Pass	Little slippage	Releases easily
Hawser used		12		Pass	Little slippage	Releases OK, requires a little unwrapping
Edelrid	Low stretch	10.5	Accessory cord 6	Pass	Slight jerks between 3-4	Sheath stretches, releases OK
Beal Baobab		13.5		Pass	Some slippage between 3-4	
Hawser new		12		Pass		Release OK
Hawser used				Pass	Some stretch. Release fairly easy	

Note: 'Pass/Fail' in the above table only applies in relation to the test and criteria employed, and may not be relevant to the safety and practicality of the item in question when it is used in any specific application



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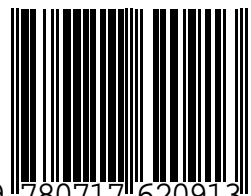
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