

SOME TECHNICAL ASPECTS OF ROCK CLIMBING.

by Paul Bradt

Part 1 - Friction

Preparatory to making a few technical notes on climbing, I looked around for Some data on the relative merits of different shoe soles. Along with the meagre handbook information one finds considerable caution given about variability of friction, as on different parts of the same rock. No climber needs to be told about such variations. He learns about them the hard way.

Two publications of the National Bureau of Standards (each obtainable from the Superintendent of Documents; Washington, D. C. for 10ϕ) have merit. The one on "Relative Slipperness of Floor and Deck Surfaces." (BMS-100) by Percy A. Sigler lists the data in my Table 2. The other, from the <u>Journal of Research of the National Bureau of Standards</u>, is by Frank L. Roth, Raymond Driscoll and Wm. L. Holt on the "Frictional Properties of Rubber", (RP-146²). It is a thorough treatment of the subject 'on which much of my discussion is based. The references left something to be desired in the way of diversity of data. I accordingly hinged a couple of timbers together (Fig.1) to provide a tiltable surface. My

Sec. 2



procedure was to put on the shoes to be tested and stand on the surface of the sample while it was jacked up. When I began to slip the jack was stopped and the slope measured. These values are listed in Table 1. In that table the diagonal lines show the slope of the rock at the time of slipping, and the numbers give the value of the slope. Figure 2 explains how this number was obtained. In that figure, r

is what the textbooks call the "greatest angle of repose". (Imagine-- repose!). The ratio of height, H, to the horizontal distance, D, I call the <u>critical slope</u>, H/D. This ratio is technically the "coefficient of friction" but I think my term is psychologically more appropriate for rock climbing.

Fig. 2 Profile view showing CRITICAL SLOPE H/D. If it were any steeper, He'd slip.



NENS

In the April 26 issue of <u>Time</u>, p. 47, an exploratory flight into the Anne Machin Mountains of West China was described. This flight was made to find a peak which was higher than Everest which was rumored to have been seen in this range. The fliers did not find a peak that compared in height to <u>**</u> Everest. * * *

On the same page one of the ladies, accompanying an expedition into the Antartica, was recognized as a former rockclimber. Some of the older climbers may recognize Mrs. Ronne as Virginia Maslin who climbed here in 1940-41.

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Eleanor and Don Jacobs have returned to Washington permanently.

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Helen Baker writes us that she only has four more weeks of study than she will be home for the summer at 4313 Knox Road, College Park, Md.

1 41 5 Y -178 No. 21 22 The Avr MA Hera steel l'Its lien Bare Sneakers with the Tricount Cleated feet. hero Soft stiff nails. robe soft rubber Clean rutter scles. iron (ner) ... 17hin soled OI'V nrils. cott on shoes soles (Nev: sole worn Socks . Bermoni 8.) leether N thin. GLASS Corrercie lplate .69 45 61 .24 17 16 to simulate guartz or obsidirn. 1.1 .68 59 58 55 96 SLATE solit with a .62 :56 10 somewhat rough surface الإيران أحاد الع <u>i i </u> 69 89 92 LIMESTONE ledge rock .89 .46 44 proked with brechiouds Frid corrl SANUSTICNE Veering some 8 63 1.05 mics A rether soft smooth piece. .67 .69 GRANITE from streem ted. Abdut ms smooth as en evelencie slope. CONGLOUOLAPE (?) A sersoned sleb of corcrete 85 formed rostly of 1/4 inch netbles. 出来 化热热热 ; TABLE I' 1. 2 11:50 and the second Criticel slopes for citienent foot seer on cry cleen POCKA. 蹲然 计输入分析分析 The figure for Pricovne or fless is too her for them on the Suertz. They bit into the gless tut coulen't serttch cuprtz. Bare fent vould have stood a higher angle on complomorate if they or their man bar bac been tougher. The socks were slightly moist, and gave higher values for smooth surfrees then they could if, cry. "The Onithe soft stones the Pricouni bite in the fre superior to Soft iron nrils. On the here rough stores the date is not decisive. After the Tricouni become yoin smooth, they lose much of their Virtue and fre thought to inferior to edge neils sho soft iron hobs.on surfrees like frenite. The shrip hore crystals of such Surfaces bite into the soit iron tetter than the steel. The Tricount neils, rrc to r lesser cerree, the edge mails the remont soles re costened to bole on herrow ledges of hero Their virtue in this is not brought but in this teble. rock. More will be seld Front this after a to an an an

ర్లు అల్లా కోహో ఉహాహారాణాల్లో లాగారు అల్లాకలాలో బిల్లెఫోడిల్లాయా బాలాబాద్ది, జోశాలాలా బాహార్కులాడిస్లా లాగారు లో లాగా ఆట్లా బాజాబాద్ని సామాలు పోహా హోటర్ల్లో జాహార్ బాలా కోహాలా లాగారు కోహా కోహాబాద్ని కోహ్యాట్లా కోహింది. కర్రాలా కారు ఎవరాలాలాను కాళ్ళాలు ఉంటాల్లా చేలు కోహింది. కోహ్ లాహార్

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Some experiments were performed by Sigler to determine the effect of dirt (r sprinkling of chine clry) and weter on floors. For these experiments actual shoes were not used but instead a sled runnershaped "heel" of leather or smooth rubber was mounted on the bottom end of a pendulum. The pendulum was swung from a support with a hole in its flat bottom and was so placed that the heel, as it swung past its lowest point, would extend slightly through the hole and rub on any floor surface the apparatus was mounted on. The slipperiness was determined by the amount of speed lost by the pendulum during contact of the "heel" with the floor. To reduce the effect of "heel" wear on the results, the "heel" was spring mounted so that it could yield somewhet in the direction of pendulum length.

This sporretus is perticularly suited to determining the effects of moisture and dirt on effloor surface. However, an obvious defect is met in studying the holding power contributed by a roughness of surface. Roughness consists of rajacent high and low spots. In use, this appearatus then rests on the highest spots and the mean pressure on the "heel" is reduced by this lifting. As the result the critical slopes listed in table 2 that apply to the roughest surfaces should be regarded as somewhat too lot.

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Dry Net Wet & & Wetl Dry Wrter, even though dirty, "Heel" 8 crn escrpe sufficiently through cleandirtycleandirtyComposit the pores of letther to increase. n non its holding power on by smooth West Barry Vermont 26.22 Leather 37 34 impervious surfree above that white of smooth rubber. This property, merble polished 80 is even more conspicuous in Smooth 34: 13 15 rope soled shows - Rubber's Rubber (honed) 1011 verkness in this motter is sometimes relaced by provid ingMinnegote 44 40 it with surfree grooves through white 8 18 Leather renite 125 202 which the wrter crm escrpe from Honed & 1.1.2 62 between the surfrees. Note, then .40 Smooth roughened however, that this problem Rubber with #189.566 eccurs enjoy smooth Minnesote 44 47 44 impervious rock. In rough :40 white Leether or percus rock the shoe need grenite provide no egress for the rough sewed .55 58 62 · · . . . • . • Smooth veter. (4-cut) Rubber is generally Rubber superior to let ther in Tennessee 46 4 49 53 holding power and it is Leether sendstone . never better than when dry 1 . 27 . 49 ground end clern. .51 flet .55 Smooth 62 Rubber: by its fine Rubber

performence deserves special \ ettention. "I eccordingly report some fertures noted by Roth et.el.

1) The virtue of rubber is largely. Friction on wet and dirty lost upon surfaces that are dirty, rock compared with dry. Critical covered with lichens or sand, for slopes for sliding friction. in such cases the rubber does not get to touch the cliff structure.

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TABLE II

2)Rubber will not start to slide on a rough, clean granite-like surface as readily as on a smooth one. In fact, the critical slope for a surface like rough granite is about .9 while that for a surface like smooth quartz may be as low as 0.45. Yet if you can Fllow F slow slippege you can stend on steeper slopes (As I did to get the figure of table I). The slow slippege of 2 1/2 inthes F minute on granite gave Roth & slope of 1.1 and on guartz & slope of 2! Note that for both friction increases with slippege, but so much more for the smooth material that it becomes much the better footing.

3) The humidity of the day does not affect the critical slope on clean insoluble surfaces, at least until the humidity is above 80% and propably not until visible moisture is present on the surface.

4) If slippege exceeds certain speeds, oscillations are set up, as when a skidding tire squeels. For such rapid movement the value of the critical slope (in this case the slope at which there would be no change in speed) drops to a value approximating that at which no slippage occurred. The figures in table II were obtained at such speeds.

5)A very smooth rubber shoe sole has definitely greater holding power on a dry smooth surface than does a rough one. Reference is not made so much here to the presence or absence of a tread design as to the smoothness seen through a high power magnifying glass or microscope. Smooth rubber has been known to hold 30 or 40% better than a slightly roughened rubber on a smooth surface. By the same token smooth rubber will hold better for a given low slippage rate on a smooth surface than on a rough one. Critical slopes of 4 1/2 have been repeatedly observed in the laboratory with a slippage of about 3/8 inch a second.

6)A rubber sole that does not chance to exactly conform to the roughnesses of the rock will normally touch the surface of the rock at only three points without being deformed. The weight of the shoe will deform the rubber sufficiently to bring a considerable part of its area into contact with the rock. The wearer's weight will increase the contact area. However, if the rubber is heavily loaded with a stiffening filler, less of it is brought into contact with the rock for a given pressure. This reduced contact accounts for the somewhat poorer holding power of stiff rubber soles when compared with soft ones.

If you don't like to remember such rules, just try the crude enclogy of picturing the rubber surface is made up of a lot of snake-like molecules each of which is itching to clamp his jaws onto r molecule of the rock wrll. When he gets r hold of it he won't let go until the rock is pulled from him. Perhapó, in the crse of slow slippinge he doesn't move but the rubber is deformed like r viscous fluid ground him. Such r picture, without regard to sny lack of scientific accuracy, would explain some of rubbers peculiarities. In case of rough rubber or rough rock only a small fraction of the rubber surface contacts the rock and only the corresponding fraction of the surface molecules adhere to the rock. With smooth surfaces, a larger area contacts and therefore a larger number of molecules rdhere. Also, in the case of slow slippage, the increase in critical slope with slippage rate would then seem to be just enother exemple of the femilier fect that it is essier to stir molesses (or rubber) when it is done slowly.

When the slope exceeds r certrin rmount, the rubber molecules re unrole to hold on; the rubber being relatively free, springs rubber-brad-like to preistively unstrained shape and then grabs hold again. The rapid repetition of this performance constitutes the oscillation such as you have when auto tires squeel. Clearly, the momentum which is grined by the sliding climber during the free period couldn't be stopped by the brief sleave unless the slope be reduced. Hence the low critical slope for sliding friction. This concept of contact area explains why rubber is the poorest footwear on conglomerate. The protruding pebbles hold most of the rubber away from the rock. This concept also leads one to suspect that a climber could probably get more performance than even the fantastic slope of $4\frac{1}{2}$ on smooth clean rock if he wore portable pancake-like rubber footholds and handholds on his feet and hands. The virtue of suction cups may have little to do with suction.

While discussing rubber it may be well to mention some results reported by Conant, Dum & Cox to the rubber div. of the American Chem. Soc. (on May 8, 1947) comparing synthetic and natural rubbers. They found that on wet roads synthetic tires had 16% greater holding power but on ice covered ones natural rubber was 8% superior. Apparently the man with the synthetic soles should lead wet pitches.

These discussions have all dealt with rock of a definite slope. If parts of the rock slope less than others, these parts are used as footholds. Suppose that the more gently sloping area is quite small, ---say $\frac{1}{4}$ inch wide. Obviously nailed boots are well suited to such small footing (if even its slope doesn't exceed the critical value,). However, rubber soles on such footing lose that part of their virtue which depends upon a large area of contact. It is the relatively poor performance of rubber on such footing and on smooth wet surfaces and on conglomerate-like surfaces that keeps nails from becoming obsolete. * * *

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Donald Hubbard				e weit of Ute Daitaee		Dolores	Alley		
Kim Karcher	, · × .		÷			Ted Sch	coredo s ad		
John Meenehan						Nick De	Sallis		

The group drove to Camp Lewis and started climbing on the backside of the Dome. From the Dome they moved downstram where John Meenehan made a complete traverse of one of the pinnacles. The climbers then concentrated or a very delicate pitch at the base of the pinnacle that took some fancy maneuvering although nearly everyone climbed it. The next attack was on the "Little Horror" which was successfully climbed. After attempting the East Face the remainder of the day was spent on an aerial traverse.

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April 4, 1948

Pim Karcher Ken Karcher Jane Showacre Andy Kauffman	Dolores Alley Billy Alley Betty Alley Arrold Weyler	11. 11. 19144 19. 1 1 . 24. 1. 6	Jan Conn Earl Mosburg John Reed
Betty Kauffman Valerie Bradt	Herb Conn Hale Bradt	· · · · ·	Donald Hubbard Chris Scoredos
One Guest from	the University of Virginia	· · ·	

Earl, Arnold, Jane Hale and Jan climbed the corner below the Fire Tower which had only been climbed previously by Chris. The rest of the group made piton leads and other climbs nearby. Dolores and Chris worked on a face near the Fire Tower. Donald, Herb, Jan, Joan and Walerie worked on a face still further away.

After lunch Joan was instructed in belaying by catching a falling body. Moving to the Butterfinger Climb, an inside corner with a hand traverse in addition to an overhang and finger and friction holds plus 60 feet of outstanding rock, many

- Frenziel e la surfa en 16 - Britz Construction (1986)

of the group battled and successfully conquered this climb. An enclosed chimney was then climbed. Other outstanding events of the day was Ken's piton lead (the lower pitons having been placed in by Andy) out of a chimney onto the face near the Butterfinger Climb and then to the summit. Donald's piton lead of the face 1 below this chimney. He was followed by John Reed and Jane Showacre. The day's activity was a source of interest and conjecture of the other less hardy sightsecrs.

April 11

Donald HubbardPim KarcherDolores AlleyBetty AlleyJane ShowacreArnold WexlerChris ScoredosAndy KauffmanHerb ConnLeonard BoltzBetty KauffmanJan ConnKen KarcherJohn MeenehanEarl MosburgValerie BradtJack WilsonHale Bradt

Carderock was visited by the Rockclimbers this Sunday. Andy, Pim, Ken and Jane Showacre traversed on the Chris-Don-Wexler Traverse. Other morning climbs were tension climbing of the two cracks near the Key Climb. In the afternoon Herb made a first ascent on a face near Leonard's Lunacy, demonstrating the smooth, flawless technique for which he is justly well-know. In the meantime, other members of the group were climbing, traversing, and ruppelling. Dolores Alley made two successful ascents of the Spider Walk. Earl and Hale were introduced to Leonard's Leap and the Barnacle Face. In the meantime Don was instructing the young ladies in the proper technique of rappelling.

April 18

Joan PriceKen KarcherDonald HubbardDoug PriceAndy KauffmanValerie BradtJohn ReedBetty KauffmanJane ShowacreEarl MosburgDolores AlleyRita McAuliffArnold WexlerBetty AlleyChris Scoredos Herb and Jan Conn Pim Karcher

Donald again cast himself in the role of teacher by instructing those climbers who were interested into the mysteries of rockclimbing. Arnold, Andy, Betty and Earl Mosburg began an assault on the face near our usual lunch spot. Chris, Jan. Jane and Herb concentrated on Sterling's Corner which was successfull climbed, even as a friction climb. Following super-instruction by Don Doug (a lad about 11) was able to climb the Overhang (an A climb), proving my theory that it was time that the adolescent climbers should replace the old men of twenty and the greatgreat grand-daddies of forty. Herb made the only attempt and the only successful climb of Charlie's Crack. Other highlights of the day was a view of fox while being pursed by hounds and the killing of a copperhead snake. Chris. Ken and Jane set up an aerial traverse on Gambs Peak four times but due to the lack of courageous leadership the traverse was never made. While playing on the peak we went to work and climbed the face.

April 25

Betty Alley Helen Scoredos Eric Scoredos Dolores Alley Pim Karcher Marion Jac son Jo, Paul, Allan and Peter Bradt Chris Scoredos

Billy AlleyJohn MeenenanHerb ConnJohn ReedJan ConnBetty KauffmanRita McAuliffAndy KauffmanDonald HubbardDouglas PriceKen KarcherEarl MosburgIt ScoredosMrs. Marble

Description in next issue.