A&E

LOOKING IN DEPTH AT ACCIDENTS, TO ASK THE CRUCIAL QUESTION: WHAT WENT WRONG?

For Steve Warner it started as a normal Saturday climbing at Burbage North in the Peak. A rare escape from Croydon, he'd been up in the area since Friday, and had progressed through the grades as confidence returned. Late afternoon, he spotted Knights Move, HVS 5a, the classic of the crag, and jumped on it.

After 10 metres of climbing, three pieces of gear were in. A good runner at two metres, a DMM Wallnut 0 at six, and at eight, a DMM Wallnut 4 in a marginal placement. Steve really needed some more gear in, but then, searching for the next placement, his foot popped. The number 4 held momentarily, but then ripped from the crack. Moments later he hit the ground.

Ten days later he was out of hospital facing 12 weeks on crutches. A permanent plate had been inserted into his heel to hold the heel bone together, and a back brace was needed to allow vertebra to uncompress.

He started to pack his gear away, resigned to a long lay off, and found to his surprise that the size 0 Wallnut had completely snapped, resulting in his ground fall. Steve explained, "this came as a total shock, I only weigh 75Kgs, I wouldn't have thought my weight would be sufficient to break the wire."

After research on the web yielded no clues, Steve contacted the BMC Equipment Investigation Panel (EIP), and sent in the broken wire. The crux of the matter is why had a Wallnut 0 (rated strength 2kN) failed due to overload of climber whose weight is just 0.74kN? What had gone wrong?

POINT OF FAILIURE

The broken wire was in very good condition, showing no other signs of maltreatment, and the breakage had occurred where you would expect, in the region of greatest stress-concentration. There were no indications of pre-existing defects, and microscopic examination showed nothing out of the ordinary. It was time to look at the details of the fall. Steve was only just above the top runner when he fell, so the number 4 ripping had very little effect on the fall dynamics. Essentially he fell from 2 – 3m above his real top runner, the Wallnut 0. That meant a fall of 4 – 6m with approximately 8m of rope between him and his belayer, giving a fall-factor of 0.5 to 0.75. This is a significant fall-factor, and it's not surprising that a force of over 2kN would be generated on the runner. In fact in tests carried out by the BMC Technical Committee, it was found that in typical fall situations it was not difficult to generate forces between 6kN and 7kN on runners.

THE FORCE BUILDS

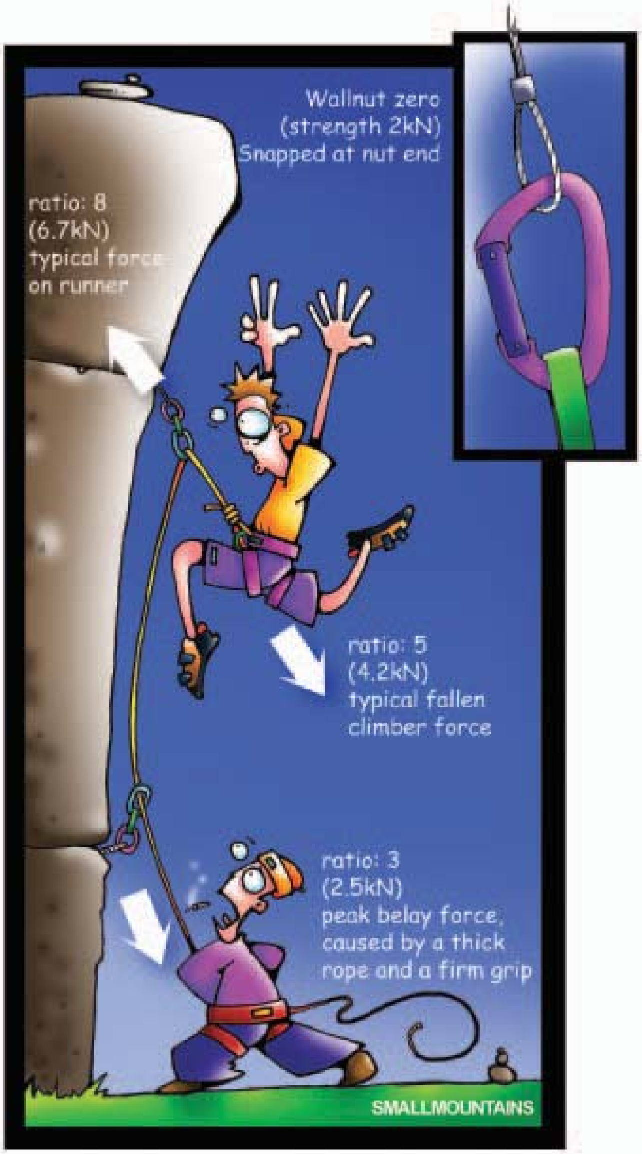
Let's take a closer look. Consider first a completely static situation with the climber clipped directly to the Wallnut. The climber weighs 75kg, so his gravitational force is (9.81 x 75) newtons or 0.74kN. This would be the force generated in the runner if he were hanging perfectly still without any movement at all. Now suppose the same climber is attached to a rope which passes up through a karabiner down to a belayer on the ground. Neglecting friction, the force in the rope will be the same on both sides of the karabiner, so the total force on the karabiner will be doubled at 1.48kN. If the karabiner were attached to a Wallnut 0, the Wallnut would not be overloaded, and would not fail. However, that assumes that the climber hangs motionless on the end of the rope. If the climber were not in contact with the rock, and say prusiking up the rope, the force in the rope would oscillate up and down as the climber moved. With over-energetic prusiking it is not too difficult to generate a peak force in the rope as much as twice the gravitational force of the climber. This would put a total load approaching 3kN on the nut, which would certainly overload it, and possibly cause failure

SIGNIFICANT FALL

Given that supposedly static situation, it's not difficult to imagine that the peak forces generated in a significant fall will easily be sufficient to cause failure. When a climber falls free for 4 – 6m before weighting the rope, the force in the rope rises rapidly until the rope starts slipping through the belay device (dynamic belaying). The peak forces at this point are determined by the geometry of the rope/runner system, the type of belay device, and the amount of hand force being applied by the belayer. Experimental measurements using popular belay devices have shown that the peak force in the rope running to the belayer can reach up to 2.5kN, reducing to less than 1.5kN with a thin rope and a slick belay device. For typical ropes and karabiners the three forces at the karabiner have been found to be in the ratio of 3:5:8. Applying those ratios to a peak force of 2.5Kn gives the forces shown in the diagram (right).

So, if the nut had taken the force of the fall, and the belayer had made a determined effort to hold the rope, the force on the nut would have been between 6 and 7kN. Even using a thin rope and slick belay device it would still have been 4kN. Given that the rated strength of the Wallnut 0 is 2KN, failure was inevitable. Of course, the actual strength of protection will be higher than the value stated by the manufacturer. The UIAA and EN standards both require the manufacturer to state a strength below that which they can ensure. Hence DMM ensure that all Wallnut 0 nuts will fail at a load greater than 2kN, and their average failure strength is actually about 3.4kN.

(LEFT) Fiddling in micro protection. Credit: Alex Messenger.



REMEMBER

All this shows that in a significant fall (fall-factor 0.5 or above), where the belayer is making a serious effort to hold the fall, the force on the top runner is likely to be between 6 and 7kN. For a climber to feel confident that their runners will hold without breaking, they should have a minimum strength of 7kN. And even this does not guarantee security, since higher forces can be generated in some high friction situations. Remember that a Wallnut 0 and all other micro protection (including nuts and some of the latest micro cams) with a similar strength rating are only intended to be used where the nature of the rock prevents the use of bigger, stronger protection. In some situations it may be possible to share the load across several micro-nuts, but if this is not possible, you should take a moment to appreciate the limited security provided, and act accordingly... **II**

Thanks: Steve would like to thank the Edale Mountain Rescue team for all their help on the day. The BMC would like to thank Neville Mcmillan for producing the original technical report, and to DMM for all their assistance with the investigation and this article.

The Equipment Investigation Panel (EIP) oversees the analysis and reporting of equipment failures and incidents submitted to the BMC. Anyone concerned that a piece of safety related equipment has failed or been the cause of an accident can complete an Incident Report Form (on the website) and send the form, along with the equipment to the BMC. An independent investigation will then be carried out.