Pilot chute pull forces compared to static line pull forces.


By

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Whats this about?

I want to give an answer to the question "does a static line jump put more or less stress on your canopy (bridle attachment point) than a free fall jump?".

PC – pull forces on a static line jump

Its quit easy to measure how much force it takes to break a break cord, i tested 2 different types of break cord (see picture 1) in the configuration that they were used in a static lines setup, a loop closed with a surgeons knot (see picture 3), then use the same connection points as for the real setup (i used a ring and a rapide link to eliminate most of the friction may result from a bridle that is shriveling that could lead to false results, see picture 2 for the setup). Put a scale on the setup and add weight until it brakes.
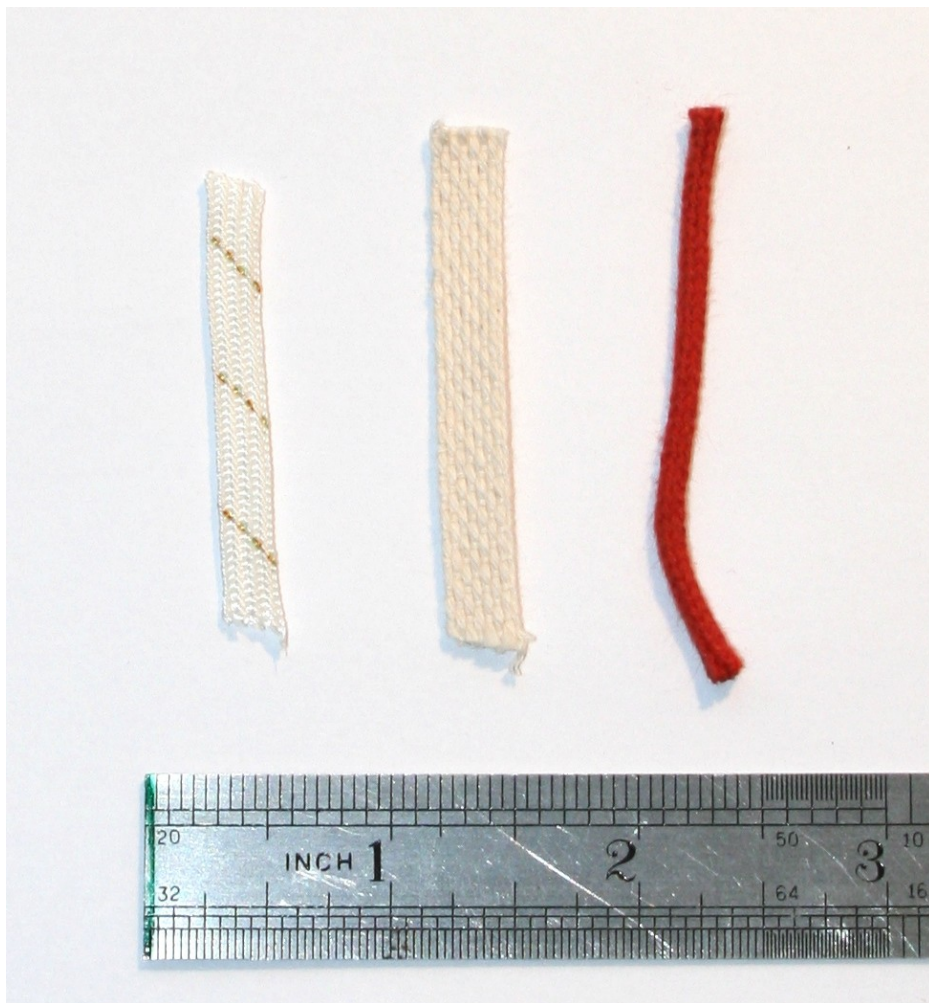
Picture 1: The used materials, from left to right:
- Type II sleeving (only on the picture to give something as comparison)
- 80 lbs break cord, white, commonly used on static lines.
- 50 lbs break cord, red, used by the army in my home country.

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Picture 2: Setup for strength measurement of the used break cords.

Break cord	Load in kg	Average ~
50lbs	33	
50lbs	35	
50lbs	36	
50lbs	36	
		35
80lbs	73	
80lbs	78	
80lbs	78	
80lbs	75	
		76

Table 1: Results of the break tests, setup as described above, loop of break cord with surgeons knot (see picture 3), although I have to add that I didn't have a exact scale for this purpose, so see this values as approximations.

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The problem with PC – pull forces on free fall jumps

Now the tricky part, measure how much the PC pulls on the canopy during opening, there are various calculations, and also measurements that state the pull force of PC of various sizes, but none of them really gives reliable data on what forces really occur during an opening. (see appendix on whats wrong with it)

The perfect thing would be something like electronic strain gauge including logging facility that does measurements in very high frequency, and all that small and lightweight enough to not falsify the measuring and to put it on a bridle and pack it together with the canopy. Since I cant get hands on such a system (if anything that small exists anyways), and I for sure cannot afford it, I had to find another solution. (if you know something suitable and affordable let me know)

So if know where to get something suitable for this job, and "black death" is only the third thing that comes to your mind when you think about putting it on a bridle, let me know!
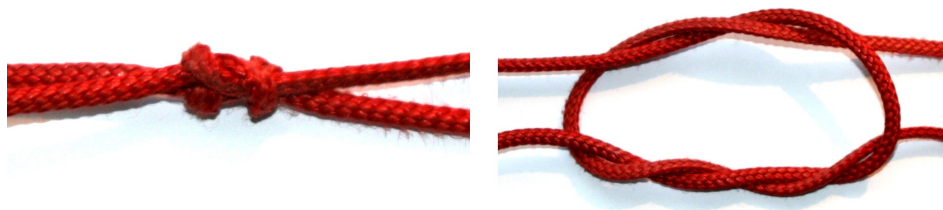
Picture 3: Surgeons knot, see http://en.wikipedia.org/wiki/Surgeon%27s_knot

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The poor-mans-bridle-pull-force-measuring-device

So back to the drawing board, since I only want to know if its more or less force than on a static line jump, theres quit a straight forward solution for this,

I present the poor-mans-bridle-pull-force-measuring-device:

Picture 4: Poor-mans-bridle-pull-force-measuring-device attached to canopy.

Putting a loop of break cord in the same way its used on a static line jump on the canopy attachment point, and voilà, we can find out if a PC pulls more than the break cords breaking strength or not. (The break cord was attached on one side to a Nr.5 french rapide link, and on the other side to a steering line ring, see pictures 2 and 4)

The downside is that resolution of this measurement method is quit bad, actually its binary, but using the 2 different types of break cord I at least got a good idea of whats going on there during opening. Also, it maybe creeps a few people out seeing something like this dangling around on a canopy, but I took care that it cannot entangle anywhere, damage anything, and theres sufficient slack bridle that the setup doesn't interfere with the opening.

The upside is, that its very light weight, measures exactly what I want and where I want, and gives a definitive answer on my initial question.

- The loop is broken = PC pulls stronger than a static line with this break cord.
- The loop is still ok after the jump = PC pulls less than on a static line with this break cord.

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The gear used for this experiment

Containers were a Zak 1 and a Gargoyle, both with Troll 265 MDV's.

Picture 5: The pilot chutes used for the experiment, from left to right.
- 36" Adreanline base made, ZP, big mesh, vented, PVC handle.
- 46" Morpheus made, ZP, big mesh, vented, foam disc handle.
- 48" Adrenaline base made, ZP, big mesh, vented, no handle.

Jumper weighs ca. 82-84 kg naked.

Results

On slider down jumps with properly chosen PC for the delay the ~35 kg of pull force of the red break cord were not exceeded (break cord still ok after the jump). So I started taking big PC to longer delays to see when its going to break and reached that point (= more than ~35 kg of pull force) at 3.5 seconds on my 46" PC.

On slider up jumps I managed to break the ~35 kg (red break cord) setup in 2 out of 3 jumps, terminal (15+ seconds) with my 36" PC, in a s-fly expert, therefore I assume that in tracking gear or slick this forces will be exceeded as well.

During the 53 jumps I did with the ~75 kg (white break cord) setup not a single one broke. See table 2 and 3 for a list of all jumps including delay, type of jump, setup, etc. (delays taken from video), "> 15.0" of course means more than 15 seconds delay.

Break cord	Object	Delay (s)	Result	Container	Info	Slider setup	PC
50lbs	B	1.0	ok	Zak	Stowed	down	46" Morpheus
50lbs	E	3.0	ok	Zak	Stowed	down	46" Morpheus
50lbs	A	3.5	broken	Zak	Stowed	down	46" Morpheus
50lbs	O	0.5	ok	Zak	Handheld	down	48" Adrenalin
50lbs	O	0.5	ok	Zak	Handheld	down	48" Adrenalin
50lbs	E	0.5	ok	Zak	Handheld	down	48" Adrenalin
50lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
50lbs	E	>15.0	broken	Gargoyle	S-fly Expert	up	36" Adrenalin
50lbs	E	>15.0	broken	Gargoyle	S-fly Expert	up	36" Adrenalin
50lbs	B	0.0	ok	Zak	PCA	down	48" Adrenalin

Table 2: 50lbs breakcord results

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Break cord	Object	Delay (s)	Result	Container	Info	Slider setup	PC
80lbs	O	0.5	ok	Zak	Handheld	down	48" Adrenalin
80lbs	O	0.5	ok	Zak	Handheld	down	48" Adrenalin
80lbs	O	0.5	ok	Zak	Handheld	down	48" Adrenalin
80lbs	O	0.5	ok	Zak	Handheld	down	48" Adrenalin
80lbs	O	0.5	ok	Zak	Handheld	down	48" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
80lbs	E	3.0	ok	Gargoyle	Stowed	down	46" Morpheus
80lbs	S	0.5	ok	Gargoyle	Handheld	down	48" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
80lbs	E	2.5	ok	Gargoyle	Handheld	down	48" Adrenalin
80lbs	E	3.5	ok	Zak	Stowed	down	46" Morpheus
80lbs	S	1.0	ok	Gargoyle	Handheld	down	48" Adrenalin
80lbs	S	1.0	ok	Zak	Handheld	down	48" Adrenalin
80lbs	S	0.0	ok	Zak	PCA	down	48" Adrenalin
80lbs	S	1.0	ok	Zak	Handheld	down	48" Adrenalin
80lbs	S	1.0	ok	Zak	Handheld	down	48" Adrenalin
80lbs	S	1.0	ok	Zak	Handheld	down	48" Adrenalin
80lbs	S	1.0	ok	Zak	Handheld	down	48" Adrenalin
80lbs	S	1.0	ok	Gargoyle	Handheld	down	48" Adrenalin
80lbs	S	1.0	ok	Zak	Handheld	down	48" Adrenalin
80lbs	S	1.0	ok	Gargoyle	Handheld	down	48" Adrenalin
80lbs	S	1.0	ok	Zak	Handheld	down	48" Adrenalin
80lbs	S	0.0	ok	Gargoyle	PCA	down	48" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	S-fly Expert	up	36" Adrenalin
80lbs	O	3.0	ok	Zak	Stowed	down	46" Morpheus
80lbs	S	3.5	ok	Zak	Stowed	down	46" Morpheus
80lbs	S	3.5	ok	Zak	Stowed	down	46" Morpheus
80lbs	S	3.0	ok	Zak	Stowed	down	46" Morpheus
80lbs	S	2.5	ok	Zak	Stowed	down	46" Morpheus
80lbs	S	3.5	ok	Zak	Stowed	down	46" Morpheus
80lbs	S	3.5	ok	Zak	Stowed	down	46" Morpheus
80lbs	S	2.5	ok	Zak	Stowed	down	46" Morpheus
80lbs	E	>15.0	ok	Gargoyle	Tracking suit	up	36" Adrenalin
80lbs	E	10.0	ok	Gargoyle	Slick	up	36" Adrenalin
80lbs	E	12.0	ok	Gargoyle	Slick	up	36" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	Tracking suit	up	36" Adrenalin
80lbs	E	>15.0	ok	Gargoyle	Tracking suit	up	36" Adrenalin
80lbs	E	12.0	ok	Gargoyle	Slick	up	36" Adrenalin
80lbs	O	3.0	ok	Zak	Stowed	down	46" Morpheus

Table 3: 80lbs breakcord results

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Conclusion

On static line jumps done with a loop of standard 80lbs break cord the forces applied to the bridle attachment point are bigger than on any type of free fall jump.

Byproduct of the jumps I did with the setup: (all values above should be understood as approximations)

- Slider down, PC size appropriate for delay, ~35 kg of pull force on bridle and attachment point are unlikely to be exceeded, although on long delays with an over sized PC this can happen.
- Slider up, PC size appropriate for delay, ~35 kg of pull force on bridle and attachment point are exceeded, with a small wingsuit.
- Never exceeded ~75 kg of pull force on bridle and attachment point. Slider up & down, terminal with wingsuit, tracksuit, slick...

I'm aware of the fact that 63 jumps is quit a small sample, I will continue jumping this setup for some time, but I'm pretty confident that I will not find out anything new.
I would like to hear what people think about this, so if you have anything you want to let me know, please do so and write me a mail or a comment on my blog.

Take care!
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Appendix, my 2 cents on mathematical models and other PC pull force experiments.

Experiments

There are tables circulating on the forums that contain the drag forces of pilot chutes at certain speeds. The measurements are perfectly good, and its nice to have data to compare pilot chutes against each other. The only thing is, thats just not what happens during a parachute opening. (its close to the forces on the bridle in the first moment of a pilot chute in tow, but thats not really what I'm looking for)

A big misconception is that those forces are applied to some part of the system during opening (be it the bridle, pc, attachment point, whatever). As an example, I know that a tank can pull 50 tons, if I now tie my bridle to the tank there will not be 50 tons of force pulling on my bridle attachment point! It'll be just the force it takes to accelerate my body to then pull it through dirt.

Mathematical models

The mathematical models I've seen are oversimplifying the problem by just leaving out parts of the system or reducing them to constants. The point is that one cannot easily spare out parts of the system, you pretty much have to account every thing, here a few examples of more or less important things to think of:

- Speed and trajectory of jumper
- Resulting pendulum effect of the jumper
- Elastic deformation of the lines
- Elastic deformation of the canopy fabric
- Elastic deformation of the pilot chute itself accounting to the then changed aerodynamic properties
- Burble produced by jumper and canopy
- Etc....

Just think about how the forces from the bridle will be transported to the dacron lines, the force is transported from the bridle attachment point on the top skin over tapes, stitching, and F111, that stretches differently depending on the angle of the applied force, and distributed to the dacron lines (mainly 4 of them).

I'm pretty sure that a mathematical model that comes anywhere close to whats happening during a parachute opening in reality is going to be fucking huge and really complex. But i would love to see a working and accurate simulation sometime...

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