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# LOGBOOK—THE ICE SHELL

## Oliver Burch, Anthony Haag, Damian Ineichen, Fabian Kuonen

Today, on the 25th January 2019, we, a team of four ice shell builders, have finally arrived in the mountains—to be precise: in Obertschappina, Canton of Grisons, Switzerland. In the preceding months, we had been calculating, testing and experimenting with different materials and methods of form-finding in specific environmental conditions. All that effort directed towards one goal: to master the art of building ice shells.

After these months of preparation, the on-site assembly of the falsework is now complete: a rigid frame out of bent reinforcement bars, attached to a glass-fiber textile, three-dimensionally seamed up, creating a doubly curved surface of 56.6 square meters. In plan: an equilateral triangle with a side length of 10 meters. In elevation: a combination of trimmed curves, with two cantilevering tips of 4.3 meters, reaching a maximum height of nearly 3.5 meters. The conditions are good: Clear blue sky, cold weather, and some hot tea boiling on the fire in the mountain hut nearby.

17:13 The last rays of the setting sun refract in the glass fiber threads, emphasizing the seams of the cutting pattern. No clouds, so every bit of warmth that the dry air can carry is clearing away into the sky. The temperature drops constantly, it is now  $-8^{\circ}$  Celsius. We are thrilled—and ready to start the freezing procedure.

19:49 After 1.5 hours of spraying, we are not freezing yet, but the textile fortunately is. Small crystallized water droplets attach to the mesh, at first as a porous network, but eventually evolving into a smooth closed surface. The canvas is stiffening, and the boundary framework neatly counteracts the increasing weight of the frozen skin.

20:56 We are now spraying the upper part of the structure. At the very horizontal spots, small icicles form as the droplets are pulled down by gravity. This is definitely not helping to close the surface, but it is to the joy of all of us. We wander around

below the ice skin, carefully detaching the icicles.

22:13 The hose has just frozen! Under the clear sky, the temperature has dropped to the night minimum—which is unfortunately too cold for our water supply system. One member of the team is unfreezing the water hose, while the others install the extra one we brought for such an incident. Huh, what a hassle!

00:41 Freezing procedure under control again. Clouds are gathering in the sky, a rather unfortunate development: Due to the insulation effect of the clouds, the outside temperature rises again. We are slowly approaching the  $0^{\circ}$  Celsius level, we hope the freezing point will not be exceeded!

01:16 Half of the team members go to sleep now. A few hours of well-deserved rest, before they get up to proceed with their next freezing shift. We, the two remaining:

A



A The Ice Shell on January 25th, 2019, at 17:09h

tired, but still finding joy in spraying the ice structure—despite the harsh conditions.

02:03 The rigid ice structure has its own frequency! We stop the icing for a while to enjoy the loud howling emitted by the vibrating ice, triggered by the soft wind gusts.

03:41 It is snowing! The temperature has again reached  $-1^{\circ}$  Celsius, heavy snowflakes fall onto the icy roof, alas! An unpleasant awakening awaits our sleeping friends—but we need the force of everybody now. The snow urgently needs to come off our ice shell!

04:15 Ice creeps: even as the «solid» state of water, the pressure and warmth make it behave like a slowly flowing mass. At this very moment we become desperate witnesses of this process. The hanging textile appears to deform towards the ground, slowly, alarmingly. It cracks whenever the water hits the frozen surface, or when the snow loads get a bit too heavy. We keep spraying carefully, but turn down the amount of water. Slightly frightened, we observe the drizzle merging into the soft layer of snow.

06:36 It is getting warmer, too warm for the water to freeze. We stop the procedure

in order not to thaw what has already been frozen. The deformation has become more severe, we hope our ice shell will survive the night. Time for some rest.

07:54 Sunrise. The clouds have disappeared again, the sun is shining onto the frozen membrane. It is wrinkled, partly deformed, but surely elegant in its own way. 1.04 tons of ice, merged into a reinforced translucent skin. No time to lose! We have to free our ice baby from its ties before it gets too warm. We carefully start to cut the sewn connections, taking away the arched reinforcement bars. Two corners are free now, the structure partly stands on its own!

09:48 Three of the four interlocked frames have been removed! One of the big cantilevering ears bravely protrudes into the sky, reaching out 4.3 meters from where it touches the ground. We take a short break, marveling at the elegance with which the thin structure defies the forces of gravity.

10:11 It is now time to untie the very last frame. Cut after cut, the small threads are being detached from the membrane. Tension is rising. And all of a sudden, we see the power of physics unleashed over our precious structure: the ice shell collapses.

Failure is the proof that you went too far. But there is a certain kind of value that comes with the lack of success: Through the precise analysis of the incident, you get a much deeper understanding of what can possibly go wrong—or where there is room for improvement. But also, and maybe even more importantly, you value the process of making in itself. And after all, since it was such a joy, you might just try again.

Watch the documentation online: [vimeo.com/channels/iceshellproject](https://vimeo.com/channels/iceshellproject)

