Cooling Oculus: A Passive Prototype

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Deserts cover a third of the earth's land surface and are growing at unprecedented rates. If envisioned strategically, deserts can be rethought as an immense resource. However, inhabiting the deserts requires architectural strategies that reimagine shelter in this extreme environment without reliance on fossil fuels.

Cooling Oculus is a project that emerged out of the question, how should one build for the desert climate? The Oculus is a prototype of a lightweight roof structure for passive cooling in hot-dry weather. It integrates two cooling strategies that compliment each other over a diurnal (day-night) cycle. These work in two ways as follows:

1. DAY
During the day the roof takes the shape of a downdraft solar chimney. To make use of evaporative cooling a light water mist sprays inside the chimney's crown, cooling dry desert air and causing it to sink down. Cool air is pulled into the interior, across a geometry informed by fluid dynamics that maximizes air distribution through the underlying space. Using this system at an outdoor temperature of 40°C, internal air can be cooled to 25°C.

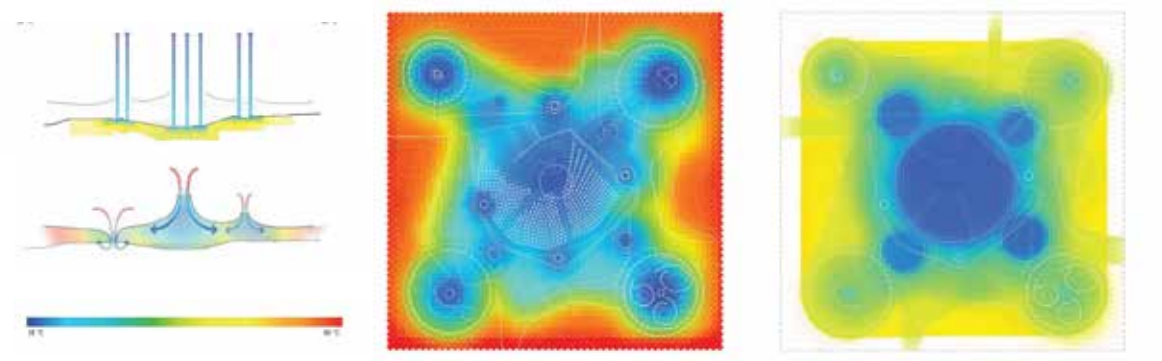
2. NIGHT
During the night the roof's chimney is dilated to open up a maximum surface of the project's concrete slab to the night sky above. With the chimney structurally deployed in the open position, on a cloudless night the cold sky absorbs heat from the concrete thermal mass depressing its temperature by 5°C and thus turning it into a huge battery of coolness for the following day.

While building on contemporary energy-system possibilities, these cooling strategies also draw from the longer tradition of vernacular desert architecture in the Middle East. For example the Bedouin tent, which relies on an adjustable lightweight roof for sun shading and the malqaf (wind catcher), which directs atmospheric airflow into a building. The Cooling Oculus makes use of a double-membrane envelope, which shades and insulates from direct sun radiation. Like the malqaf it draws air into the interior volume, but regulates airflow precisely through a hyperbolic geometry. The dilation of the chimney at night is made possible by a triangulated geometry of lightweight tubes and a hinged mechanical joint system.

The development of the project began with a parametric model developed based on airflow calculations. In the past months, a large-scale prototype has been constructed in order to resolve the material and mechanical requirements of the system and it is now being tested for its airflow and cooling capacities in lab conditions.

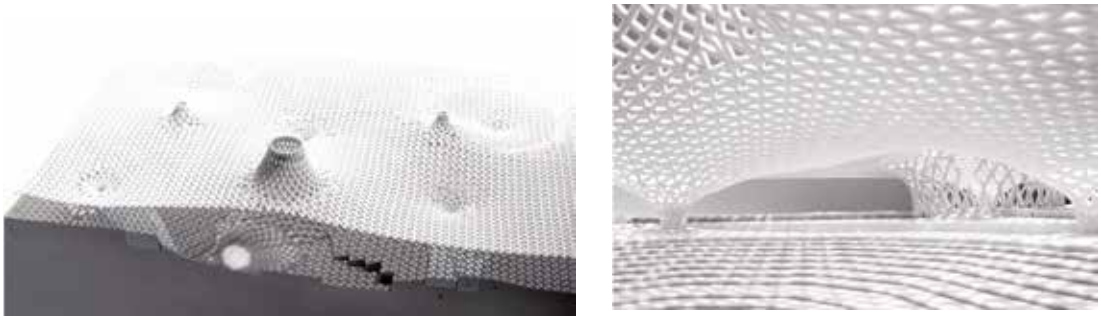
1 NIGHT AND DAY TEMPERATURE GRADIENT

Diagrams demonstrate the air cooling during the day and the slab cooling during the night



2 STRUCTURE AND ENVELOPE

A lightweight grid-shell structure is coupled a double-membrane envelope to shade and insulates from direct sun radiation



4 PROTOTYPE DEVELOPMENT

Using hyperbolic geometry and mechanical joints, an operable prototype was developed. Below see its construction process

COOLING OCULUS

A PROTOTYPE FOR PASSIVE COOLING IN THE DESERT

Integrating evaporative and radiative cooling along a diurnal cycle