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Porous Adaptive Membranes

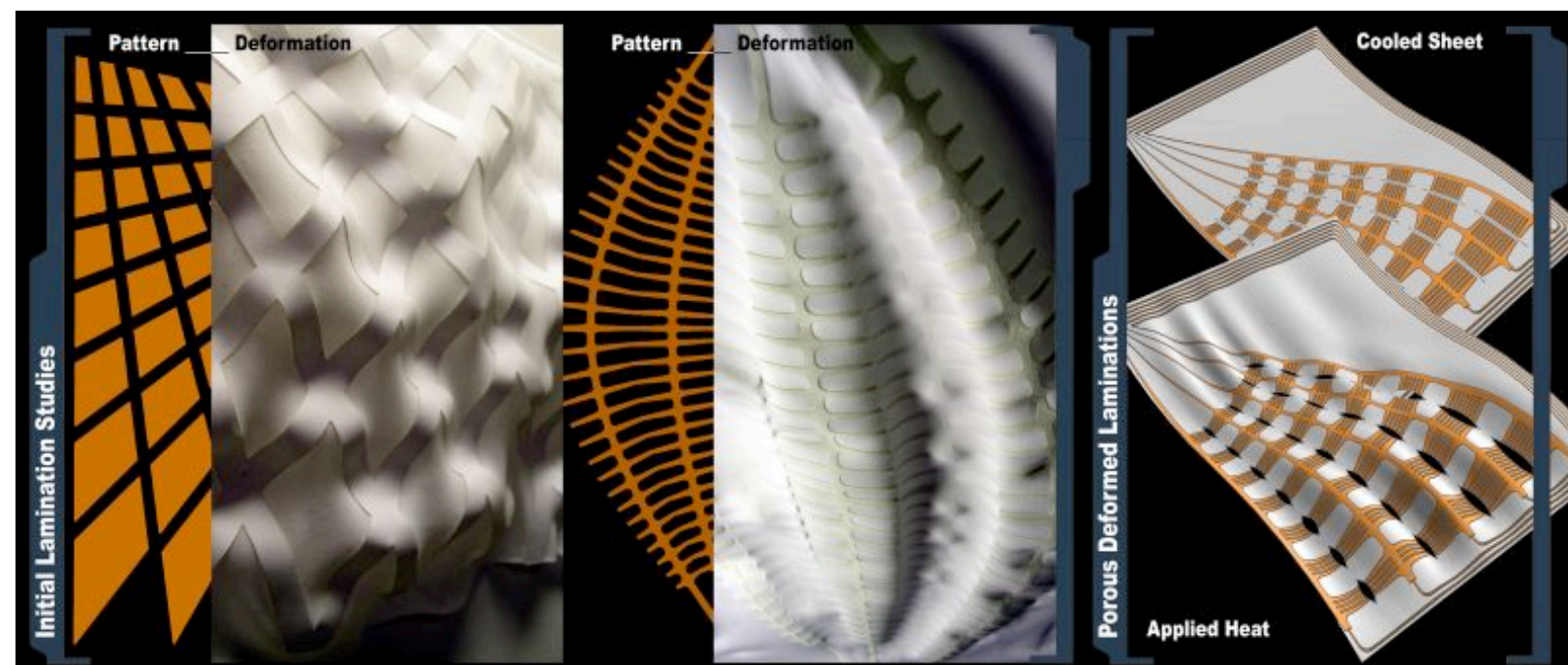
A Clinic for Doctors Without Borders

The goal of the study was to design an 'adaptive system' in an effort to achieve a higher degree of energy optimization in a built environment. This goal narrowed to become a system that automatically ventilates according to a changing thermal environment to maintain a comfortable interior temperature.

To approach an adaptive system it is reasonable to begin with a responsive detail. In exploring this detail, planer buckling that occurs due to differences in thermal expansion between two laminated materials was employed to effectively actuate small pores within a silicone membrane. After many empirical studies and finite element analyses, the detail of the pore was developed. These pores can be programmed through manipulation of morphology and constituent material properties to open or close with changes in ambient temperature and solar gain to allow ventilation. When distributed across an entire membrane in an architectural context, a self-adjusting thermal flue can be created to regulate the temperature of the air within the membrane. The solar orientation becomes critical to the proper operation of the membrane; form optimization is derived about solar radiation absorption, wind speed and turbulence.

The consolidation of several performances within one primary system lends itself to lightness and portability which leads to the displayed manifestation of the adaptive membrane as a portable Clinic for Doctors without Borders. Clean water must be stored on site for sanitation and drinking; the foundational ballast bladder is used to filter and store local water. As the bladder is filled, it deploys the structural masts and tensions the membrane. The bladder is oriented to absorb solar energy, utilizing the water as a heat sink to further assist operation of the thermal flue.

In the end, the project was realized not from the larger context to a small detail, but rather the other way around: beginning with a thorough first-hand exploration of materials and their latent tendencies and possibilities to construct an authentic detail.



1] The provocation for the Porous Adaptive Membrane is a study of material tende

Thermostatic Pore Composition

Circuit:
This is potentially included to override thermal deformation due to ambient temperature

Widened, rounded strip end:
To distribute force of shear and buckling without delamination stress accumulation about corners

Seam:
To prevent reciprocal buckling due to extreme temperatures; it can only open one direction

Strip:
This form is used to bias the thermal expansion in only one direction

Strip array:
Many strips are used to cup the surface of the membrane to facilitate translation of air from side to side

Finite Element Analyses of Pores

2] The deformation of two laminated materials with differing thermal expansion rates is employed here to effectively open and close a small pore in a membrane. As the surface is heated by the sun, the pores open and vent.

Ventilation Strategy

85+ degrees F

A water bladder is used as a heat sink and foundation system. Pore Zones (A+B+C) Engaged

45-65 degrees F

As the exterior temperature raises, different zones of pores open to vent. Pore Zones (A) Engaged

Deployment Strategy

As the water bladder inflates, it raises the masts and tensions the membrane.

1

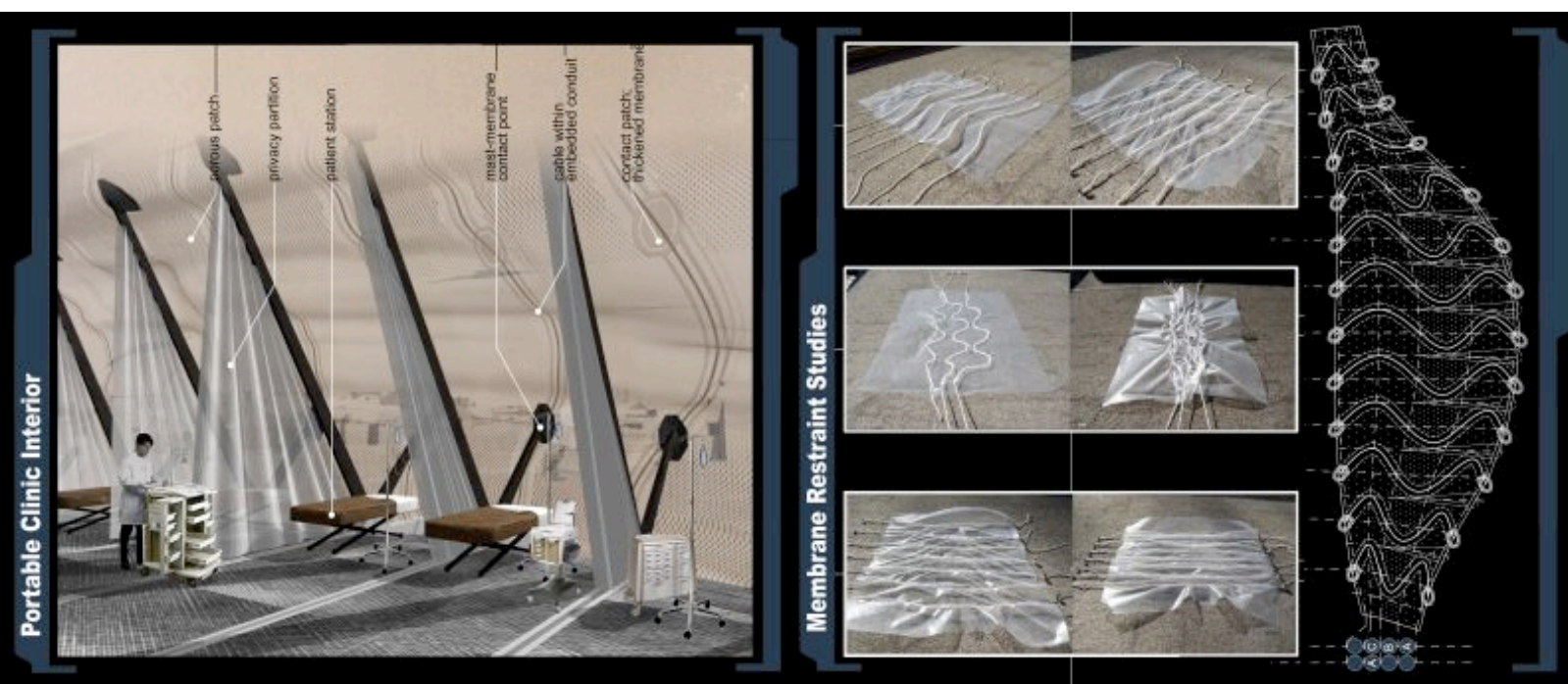
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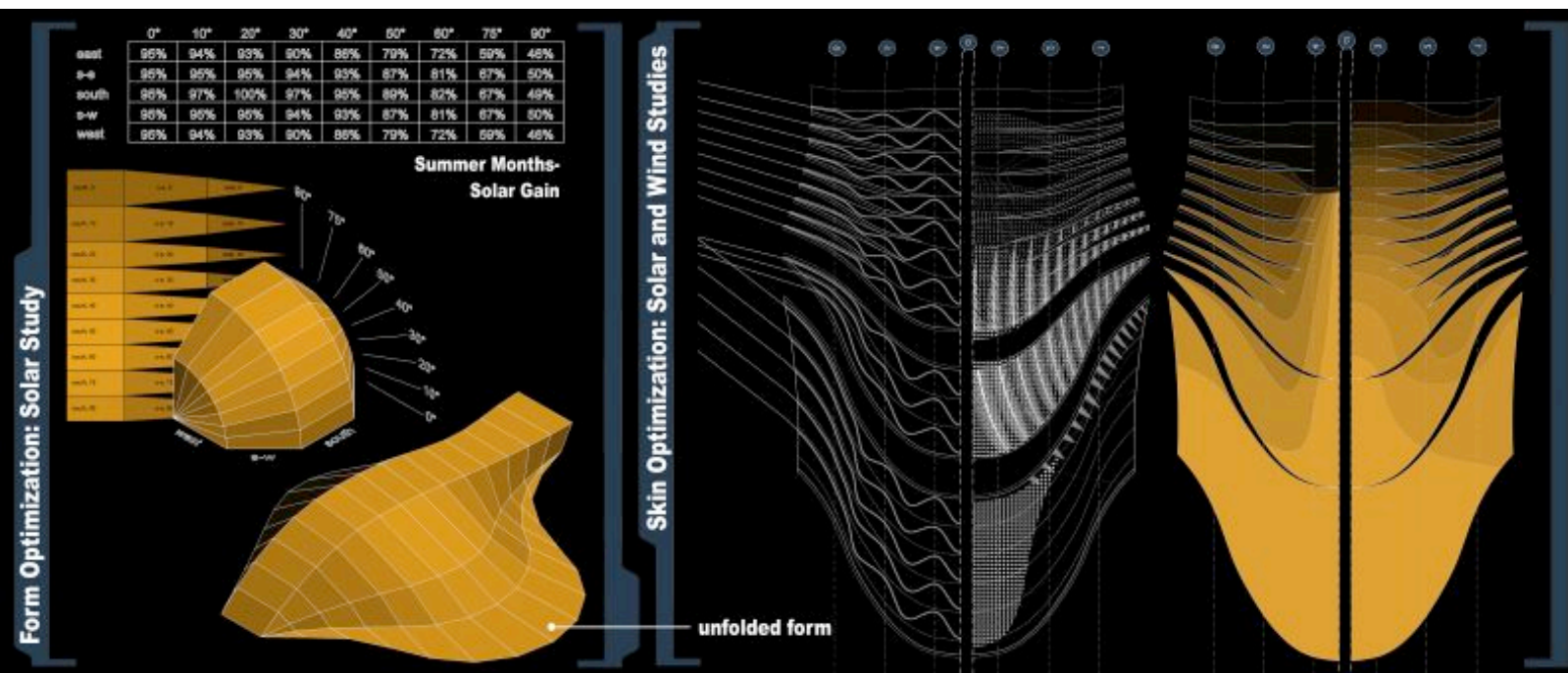
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water bladder

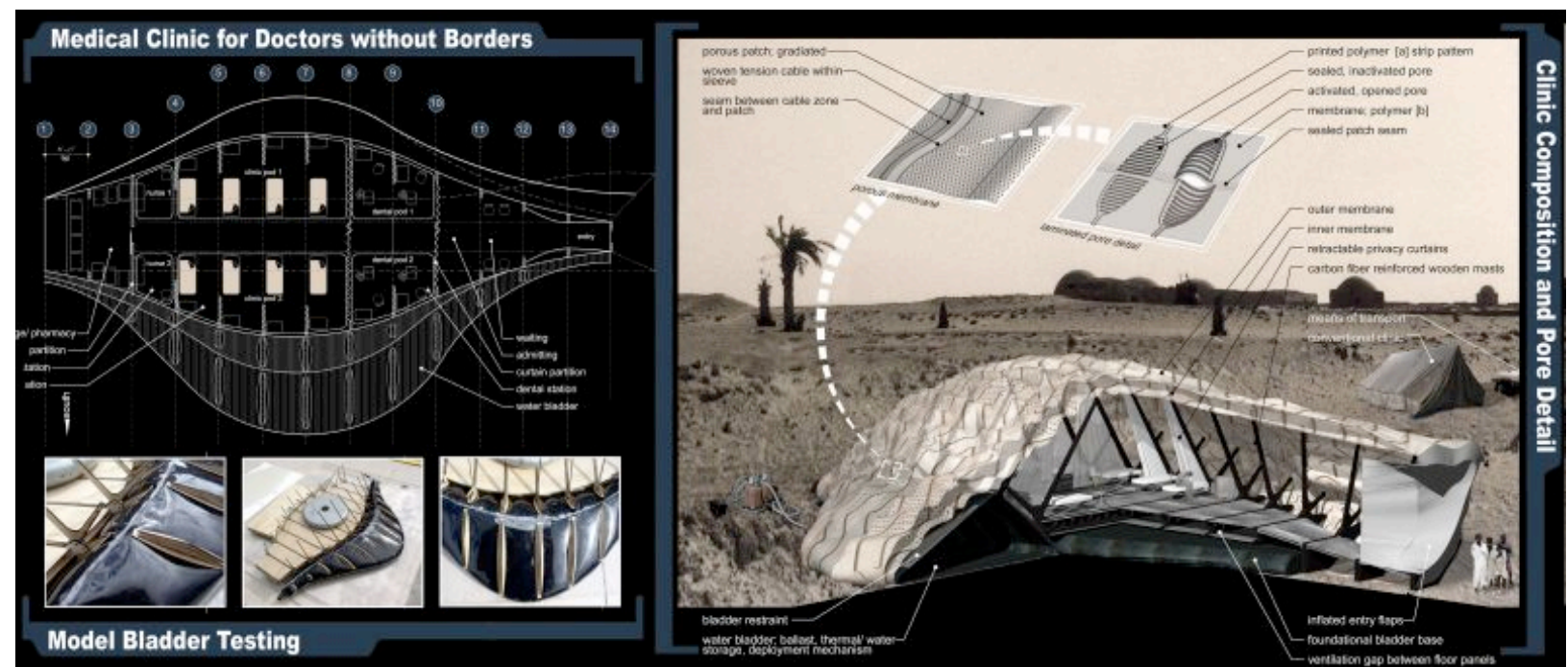
3] Two porous adaptive membranes join to create a barrier between inside and outside while forming a thermal flue. A water bladder is used as a foundation for the structure which serves as a heat sink for the flue and as a deployment mechanism.



4] Unlike conventional membranes, the Porous Adaptive Membrane cannot be highly tensioned as it would affect pore performance. Instead, a “wrinkled” restraint system was devised through empirical testing where sinuous cables are pulled tight, effectively shortening the unsupported span of the skin while increasing the surface area to accommodate more pores.



5] The thermostatic pores of the membrane respond to solar gain. Given this, the entire surface form is derived through solar radiation analyses for different seasons given a latitude of 32 degrees.



6] The consolidation of several performances within one primary system lends itself to lightness and portability which leads to the displayed manifestation of the adaptive membrane as a portable Clinic for Doctors without Borders. In addition to the aforementioned functions, the foundational ballast bladder also serves as a storage tank for drinking water.

Project link: www.archiprix.org/project.php?id=2279