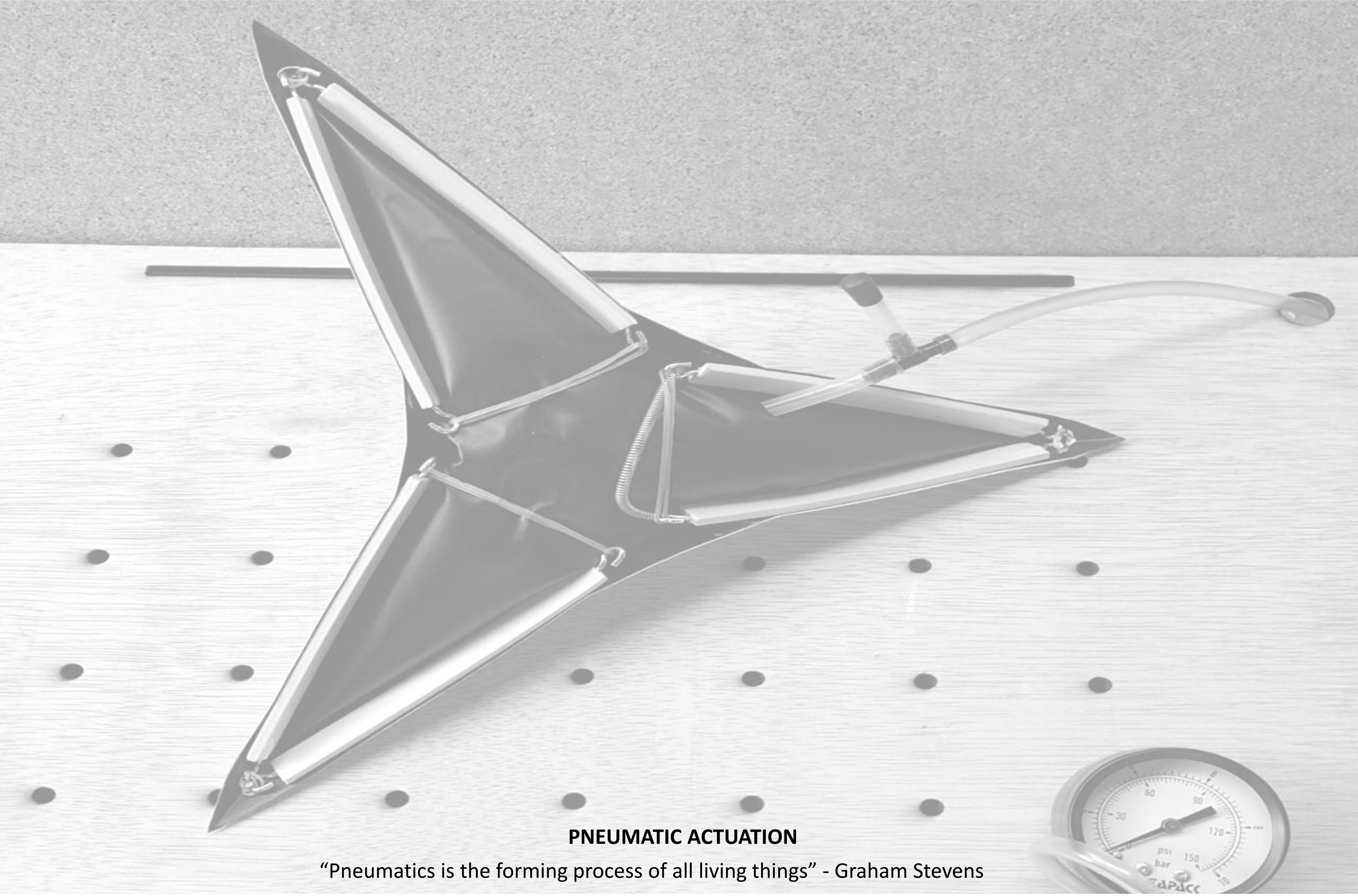


PNEUMATIC ACTUATION

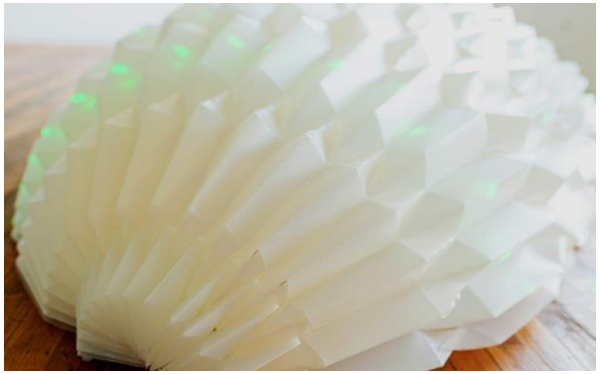
“Pneumatics is the forming process of all living things” - Graham Stevens

DEFORMATION BY INFLATION

A Pneumatic system is one where surfaces deform from internal pressure or gravity compression. A building footprint can be developed into an. arrangement of passages and domes using such a system. The air pockets are maintained by seams which can be compared to stained glass paintings. This progressive and lightweight alternative to normal architecture construction has renewed relevance to current re-evaluation of energy use and new forms of climatically responsive envelopes.

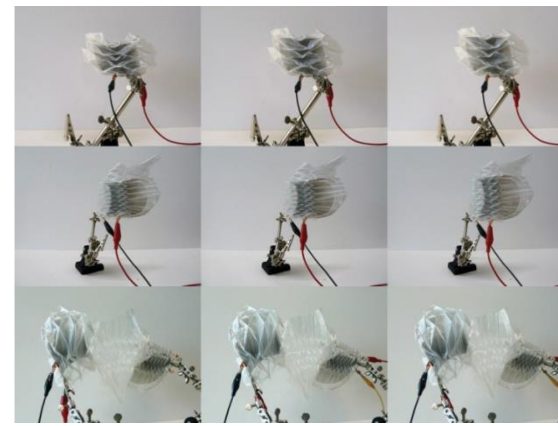
The experiments explore how force at the point of least resistance or at the point of maximum deflection can deform or transform a geometry. A geometry is introduced in a controlled pneumatic system to analyze how varying parameters of air inlet/ outlet, pocket pattern and arrangement, anchor points and floating points, pressure, time and material can affect the translation of a geometry from a state of equilibrium to a state of inflation.

Pneumatically Actuated Deplorable Structures
Jeremy Luebker,AdreaSpringer



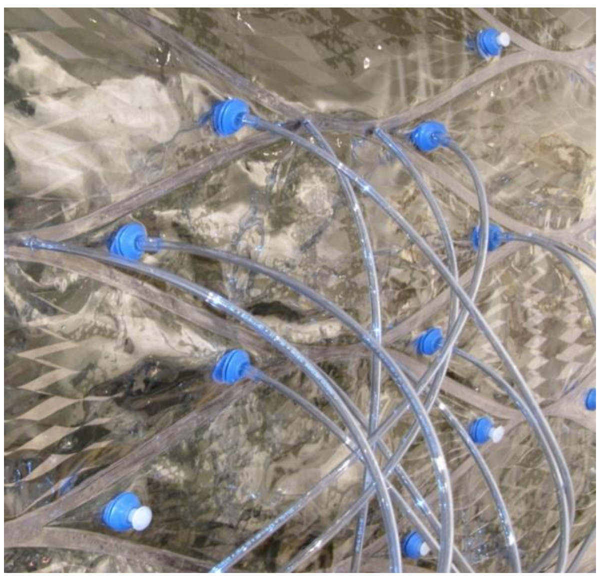
http://archinect.com/people/project/68194212/p-a-d-s pneumatically-actuated-deplorable-structures/78921054

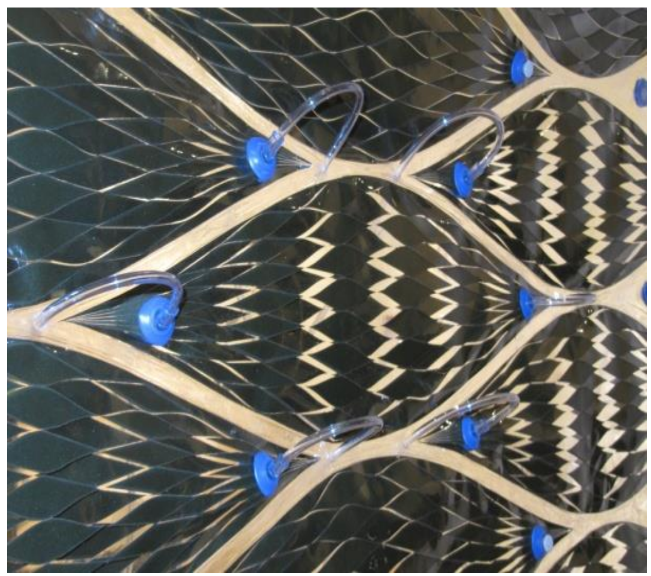
Animated Textiles
Responsive design studio



http://fashioningtech.com/profiles/blogs/animated-textiles

Pneumatic Envelope
Rick Sole

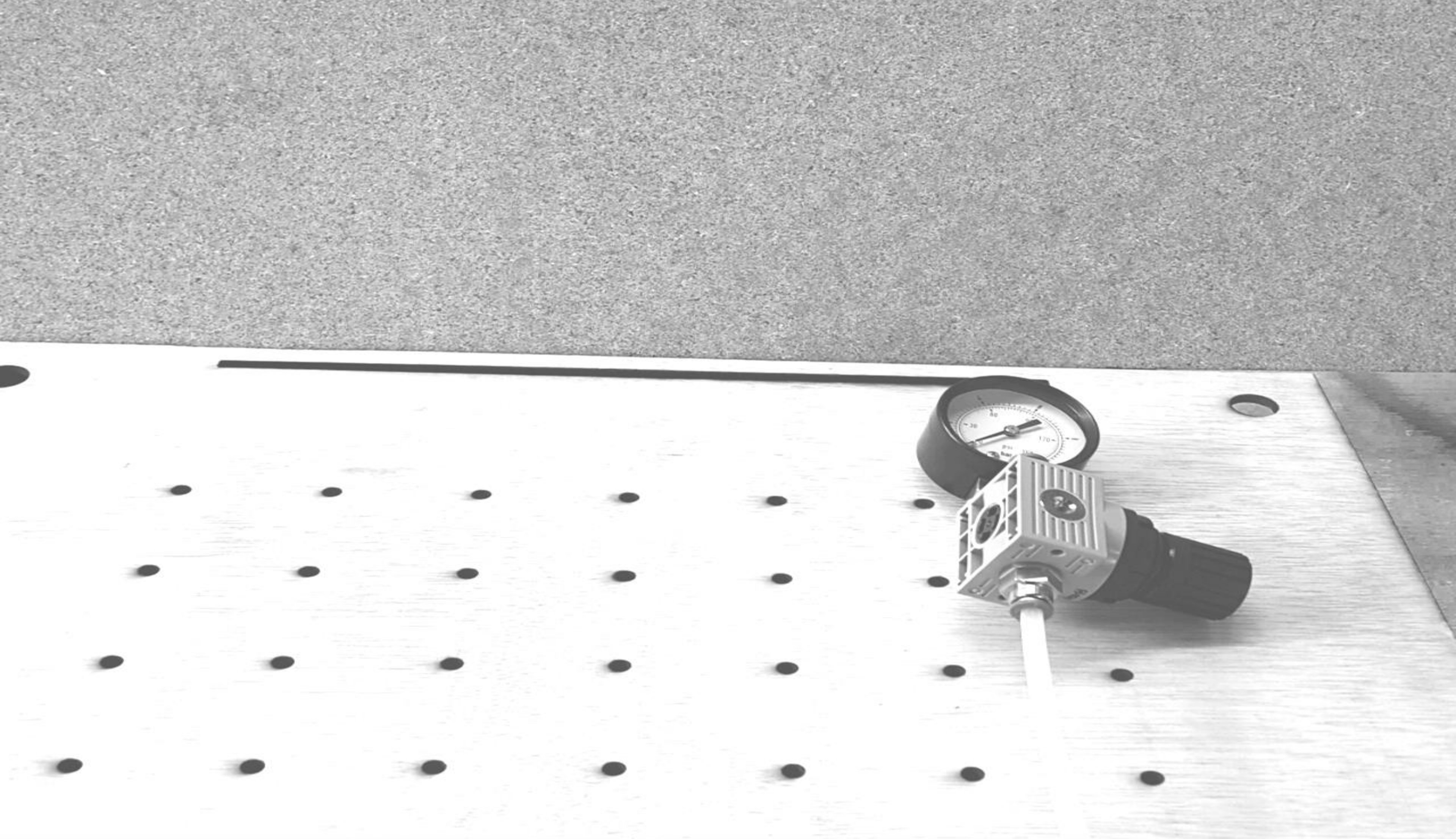




http://rad.daniels.utoronto.ca/poly-glazed-curtain-wall/

INFLATION TEST

MATERIAL / AIR PRESSURE /GEOMETRY/
SEAM PATTERN



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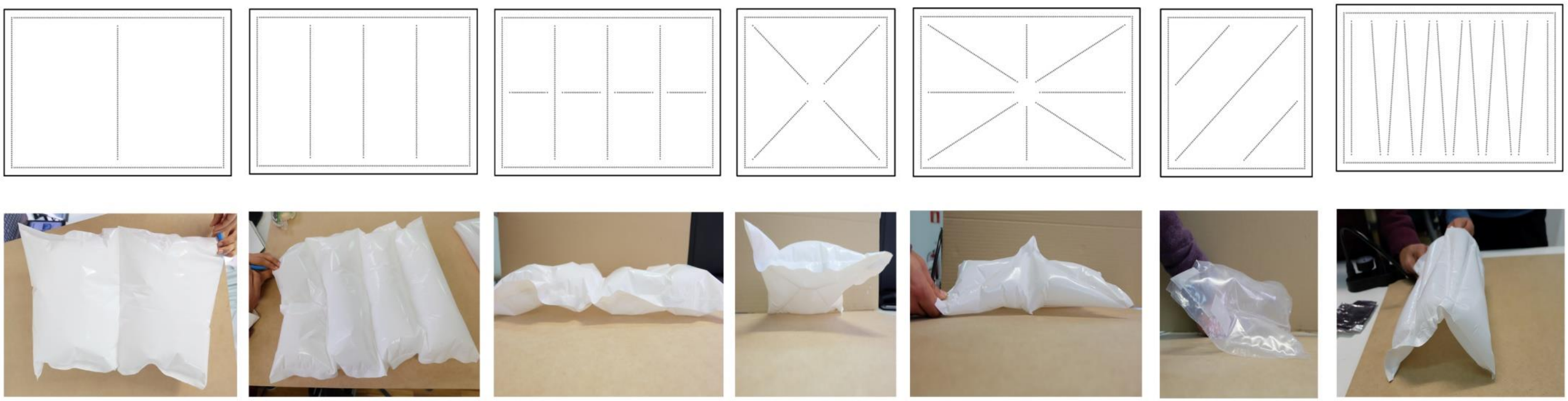
BEHAVIOUR: INFLATION

MATERIAL : PVC

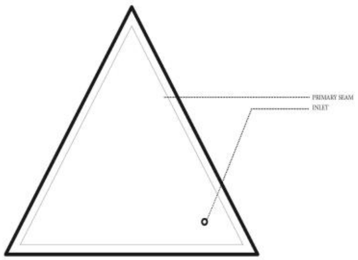


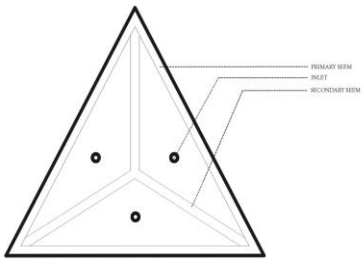
Conclusion

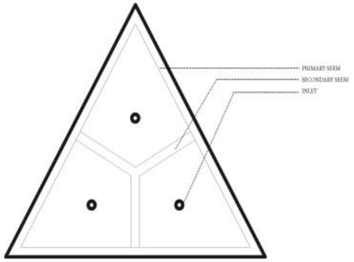
The relationship between pockets defined by seams in the collapsed state to inflated state was explored. While the pockets allowed air to separate its membranes the seams were the restricting force. The strength of the pockets was varied by the width of the seam and the method of membrane bonding. Leakage and tearing in the membrane occurred at the seams and not at the point of maximum deflection.

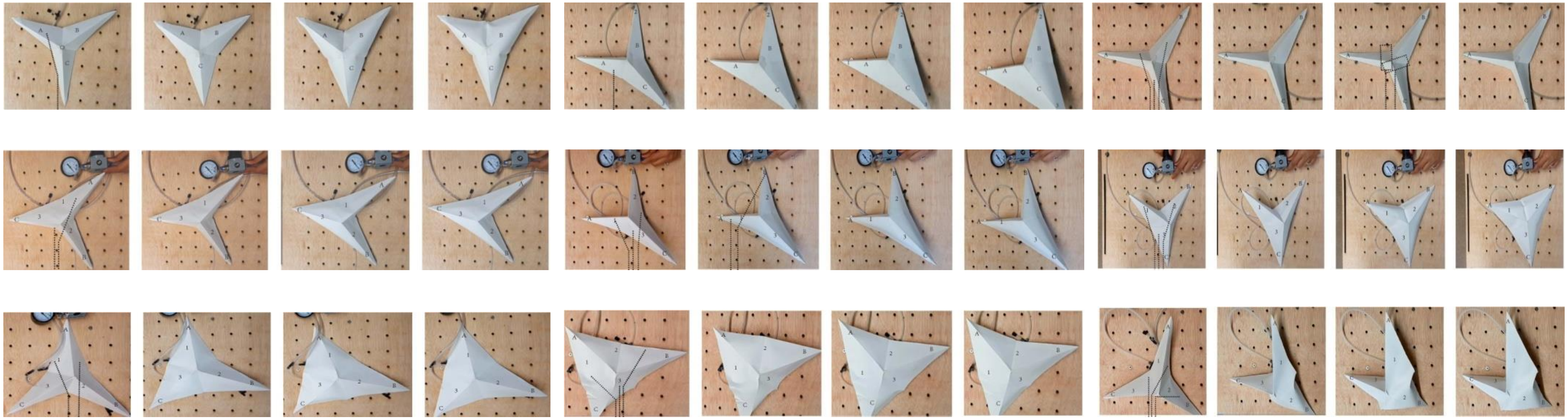
GEOMETRY PATTERN

MATERIAL: VINYL





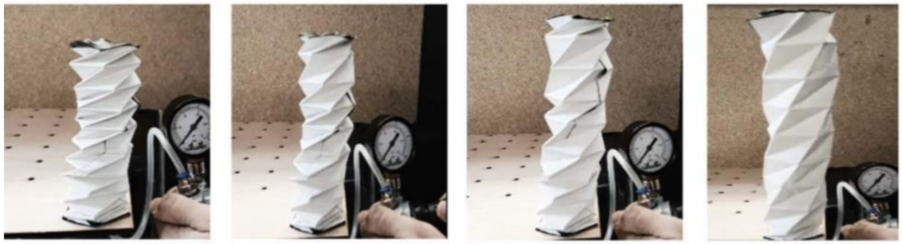




Conclusion

A triangular element is made with a hybrid system of rigid and soft materials. The rigid frame is folded to collapse when deflated. The soft membrane pushes the folds out to realize its fully expanded state. The parameters varied to control the movement of the geometry through inflation were the pressure, anchor points, resistance bands between vertices and the arrangement of pockets.

MATERIAL: VINYL/ PAPER



Conclusion

The pentagonal pattern is the most efficient collapsible for inflation. It allows for up to 200% expansion from a collapsed state. The rigid material once over a threshold of 100% expansion does not easily assume its original form once deflated and has to be refolded. Below this threshold it can safely expand and revert back to a collapsible state without an external and opposite force.

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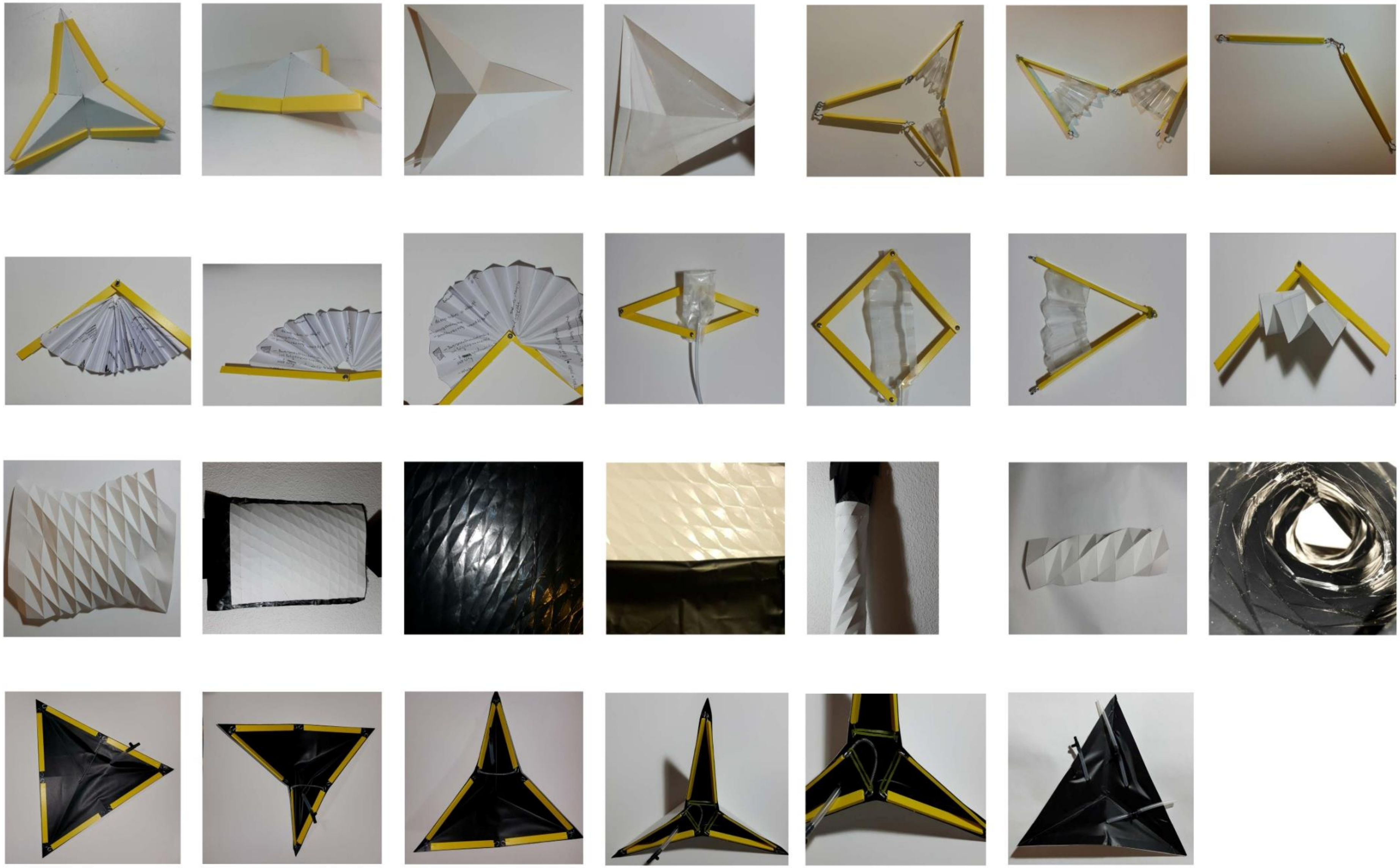
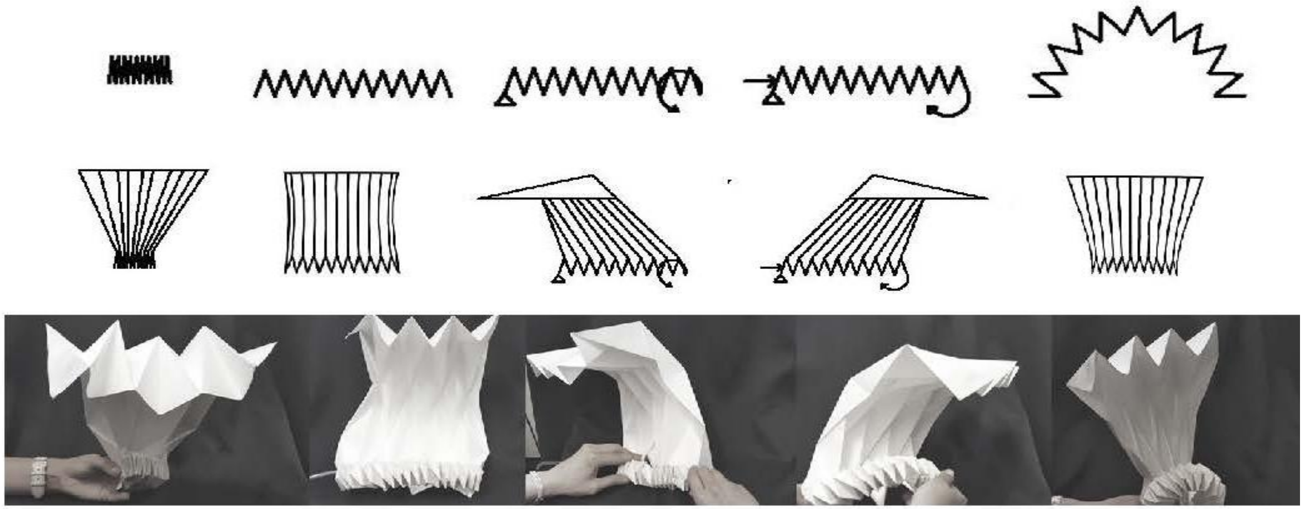


MATERIAL: PAPER



To understand the limits of a movable structure that is pushed by two collapsible legs we adapted the folding principles of origami in two scales. The structure was pushed to exhibit a linear and curved linear movement by inflation of the legs in sequence. The structure is a rigid collapsible frame embedded with resistance bands to bring it back to equilibrium. The legs were horizontal collapsible towers that push the structure. The organization of fixed points in the towers govern the direction of inflation and hence the movement of the structure.

FRAME AND SKIN

A Miura origami pattern was used to create a paper cast for latex. The paper is first oiled and the latex is then coated onto the paper in thin layers. The angle of the folds is varied during the drying of the latex to see the effect on the elasticity of the dried latex. The scale of the folds was also varied. The next step is to maintain rigidity in the latex without the cast.

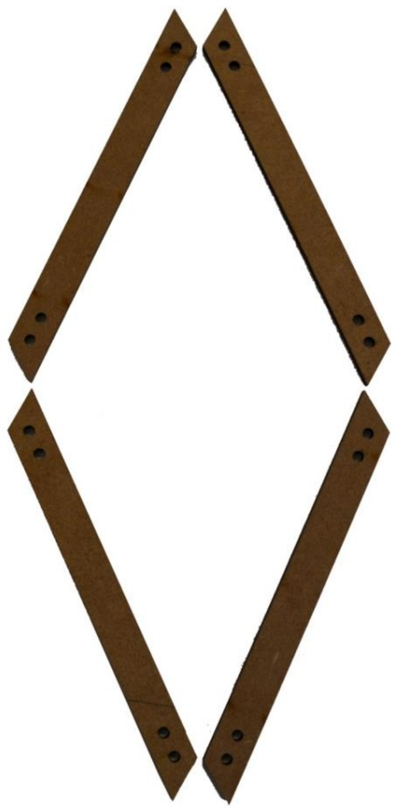
The composite of paper and latex exhibits properties of both materials and assumes its original semi folded state when stretched and released. The material is also flexible and has a higher threshold of failure.

http://hellomaterialsblog.com/2014/10/01/orimetric-rubber-origami-driven-material-exploration/

AIR AS A FLUID

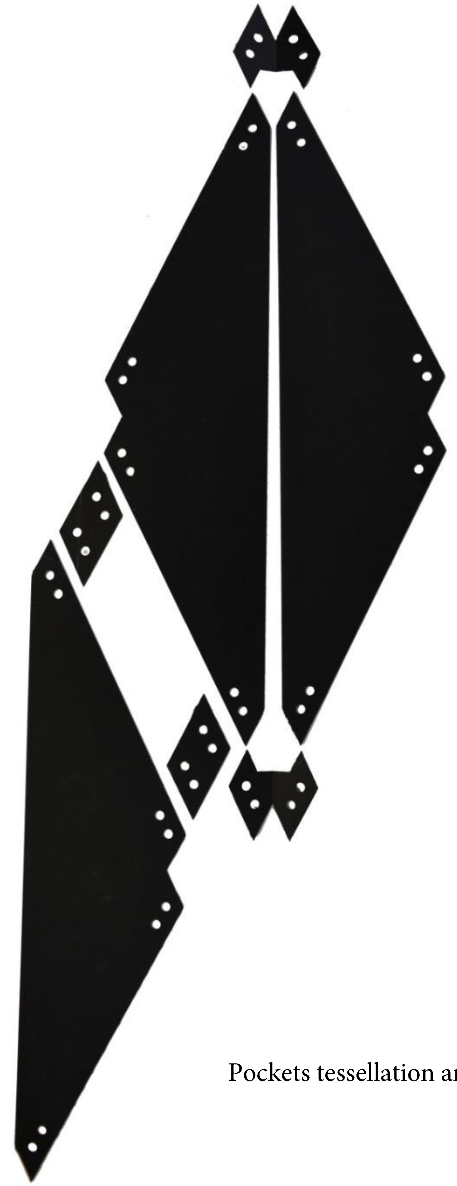
Our investigation into pneumatic actuation was towards translating geometry from a collapsed to realized state. The geometry can be set to have a minimum footprint and in an occupied building would develop an arrangement of passages and domes. The energy exchange would be natural and wastage would be minimal. Air as a fluid would be used to actuate a hybrid system of hard and soft materials that can collapse of their own accord and be deformed or formed based on the variation of interior air pressure and the allowance of the frame supports. This would take the system closer to a growing, living and informed structure that could deform according to preset conditions and perhaps improvise even.

COMPONANT & JOINTS

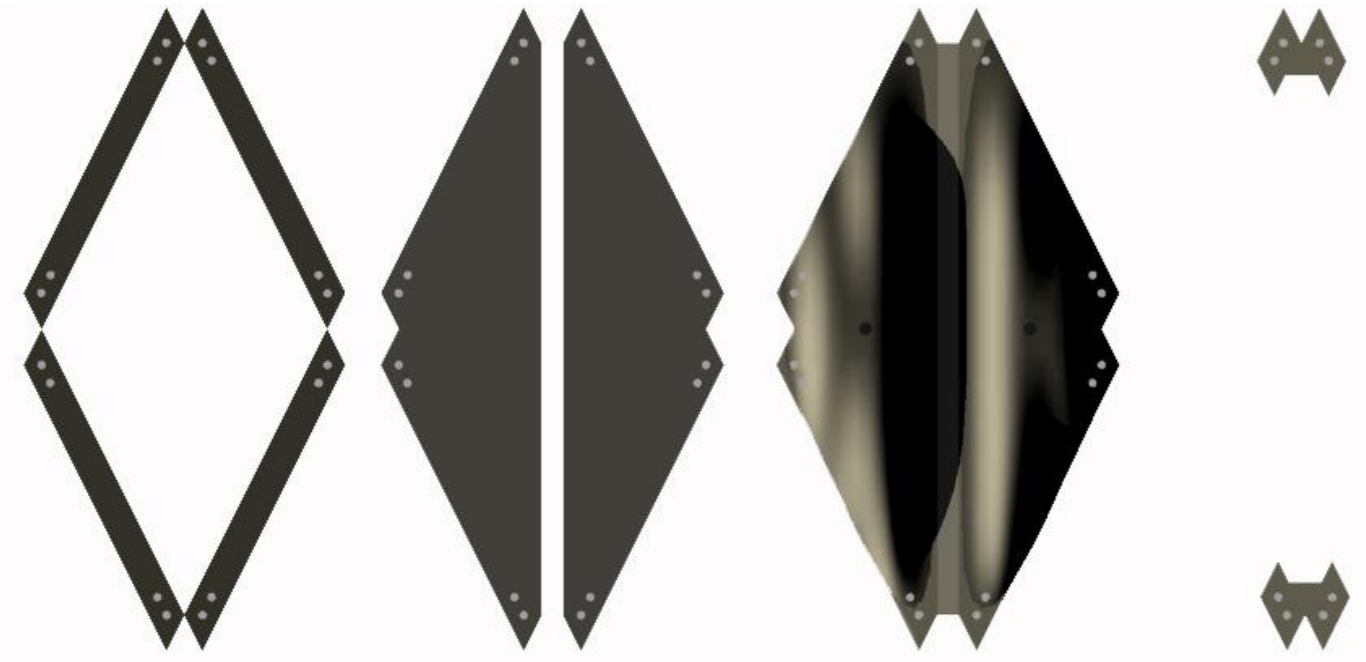


Single component
Frame
Material : MDF
Thickness: 3 mm
Density: >700 kg/m3

Frame pocket and joints
Material: PVC
Thickness: 2mm
Density: 1.1 – 1.45 g/cm3



Pockets tessellation and joints

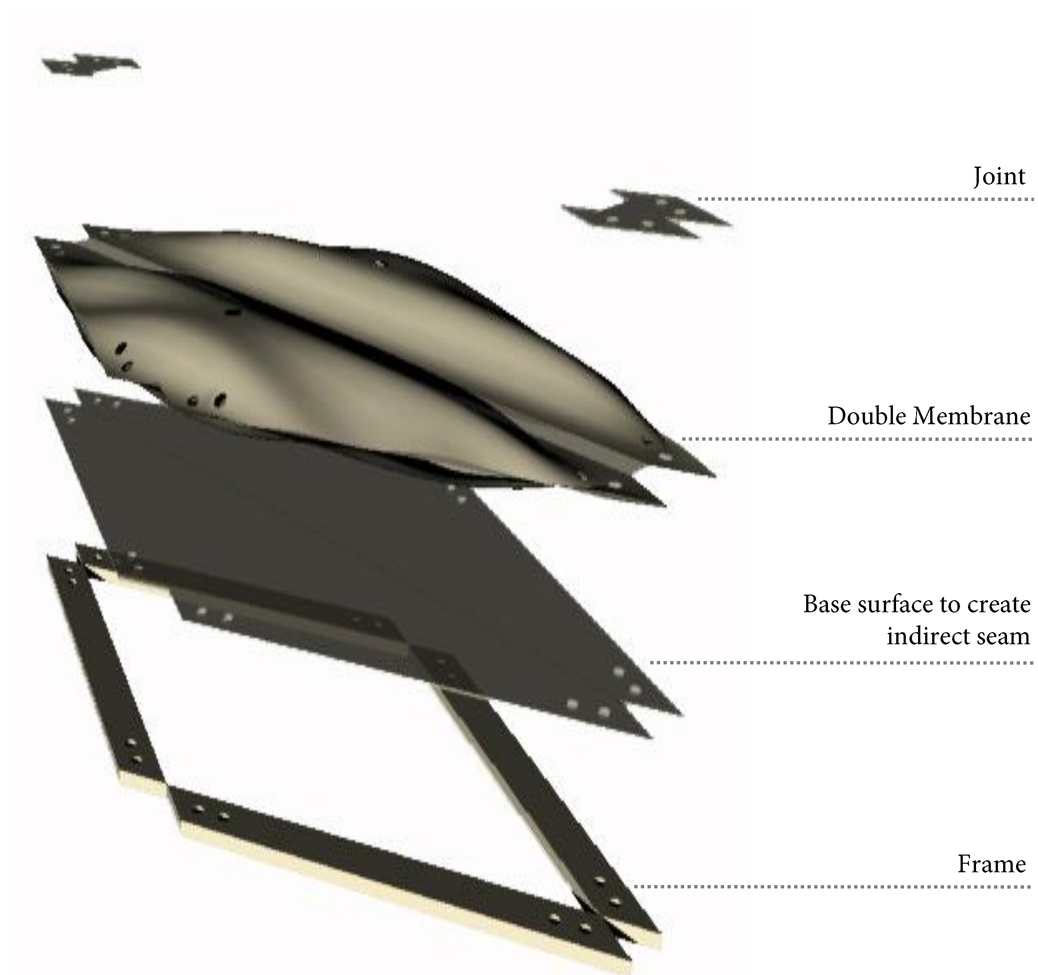


Frame
Material: PVC
Thickness: <2 mm
Density: 1.3 – 1.45 g/cm3

Base layer for pocket
Material: PVC
Thickness: <2 mm
Density: 1.3 – 1.45 g/cm3

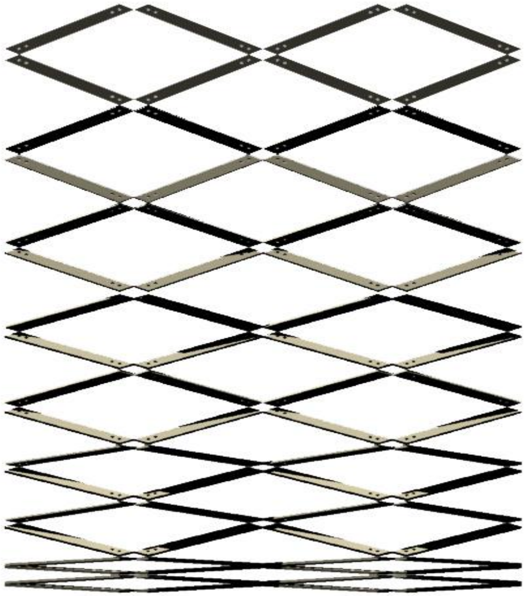
Double Membrane
Material: PVC
Thickness: <2 mm
Density: 1.1 – 1.3 g/cm3

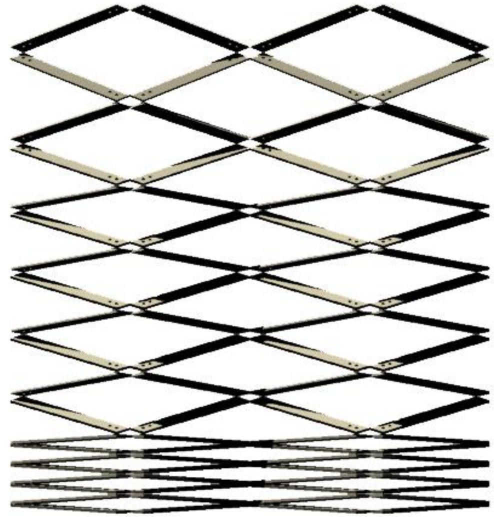
Joints

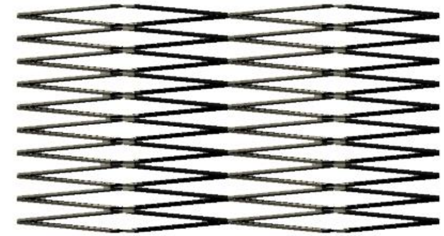


Component layers: frame / double membrane/ joint /

Component layers: frame / double membrane / joint /







State: Inflated
Expansion: >75%
Pressure: <1 psi

State: Deflating
Expansion: >17%
Pressure: <0.5 psi

State: Deflated
Expansion: 0%
Pressure: 0 psi

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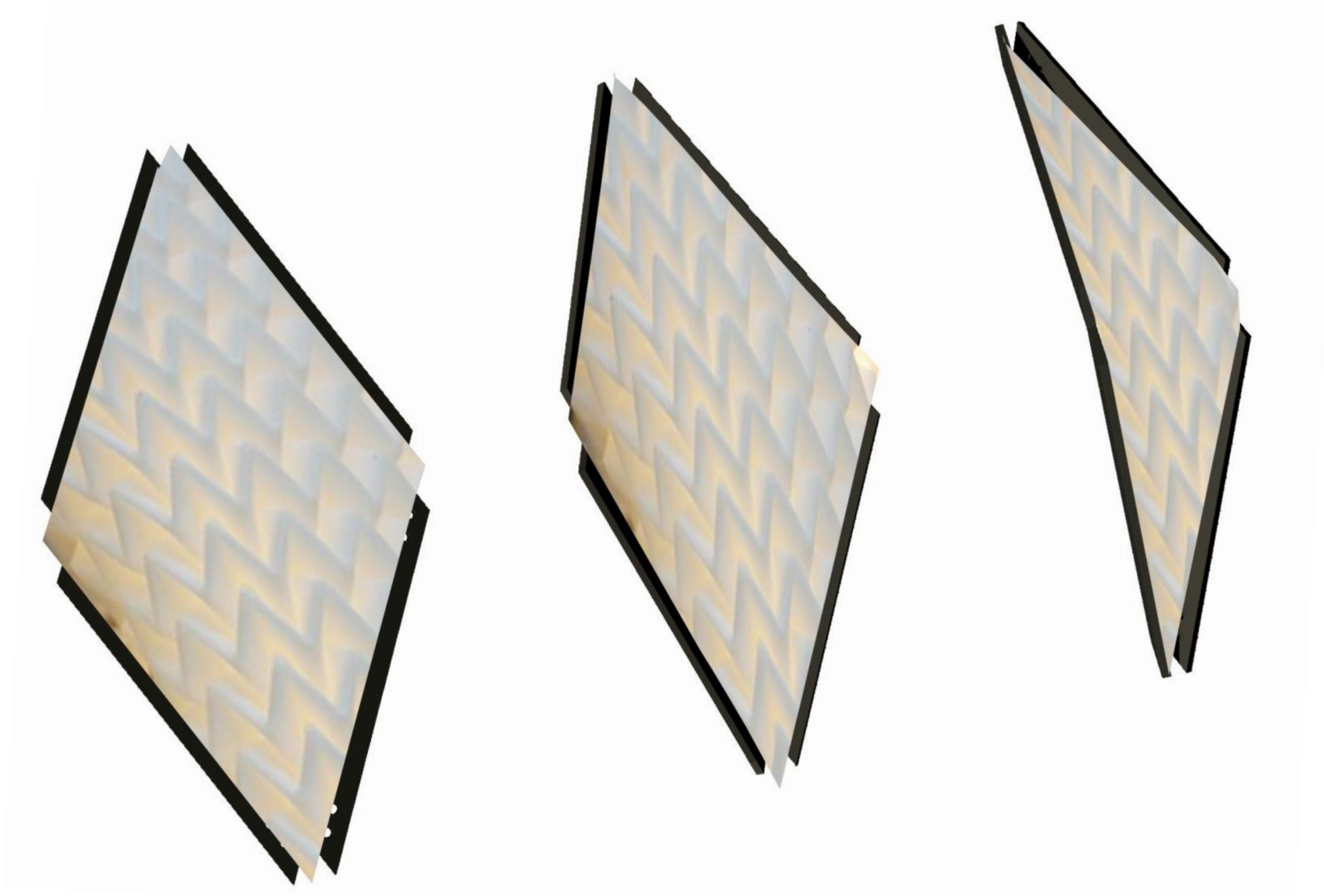
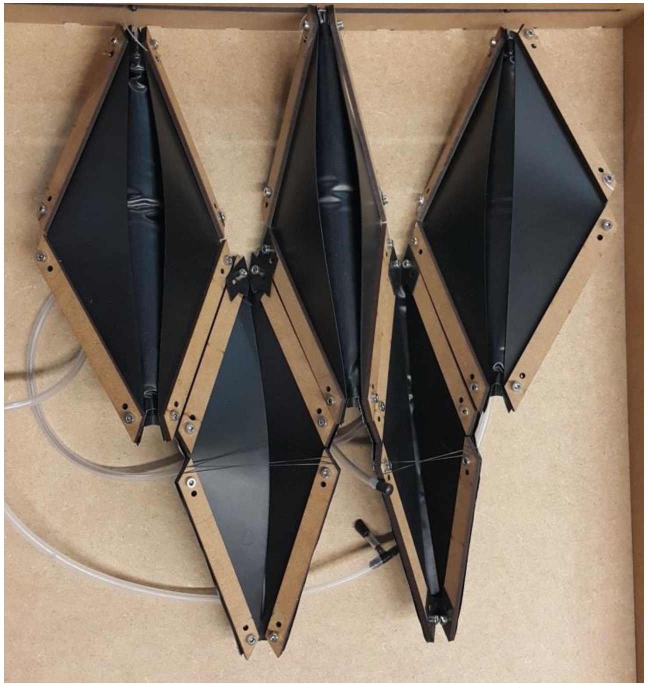


conclusion

The span of expansion can be controlled by varying the pressure of the pockets individually or in combinations of series or parallel. A group of 6 panels can be inflated to full span with a pressure of under 1 psi without permanent failure or leakage. The panels return to the original state in the same time frame.

Application

The panels can be used to form a light weight adaptable shell skin that when combined with a frame can provide shade and protection from the elements.



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